SEPTEMBER 17, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

Bronze Sleeve Bearings

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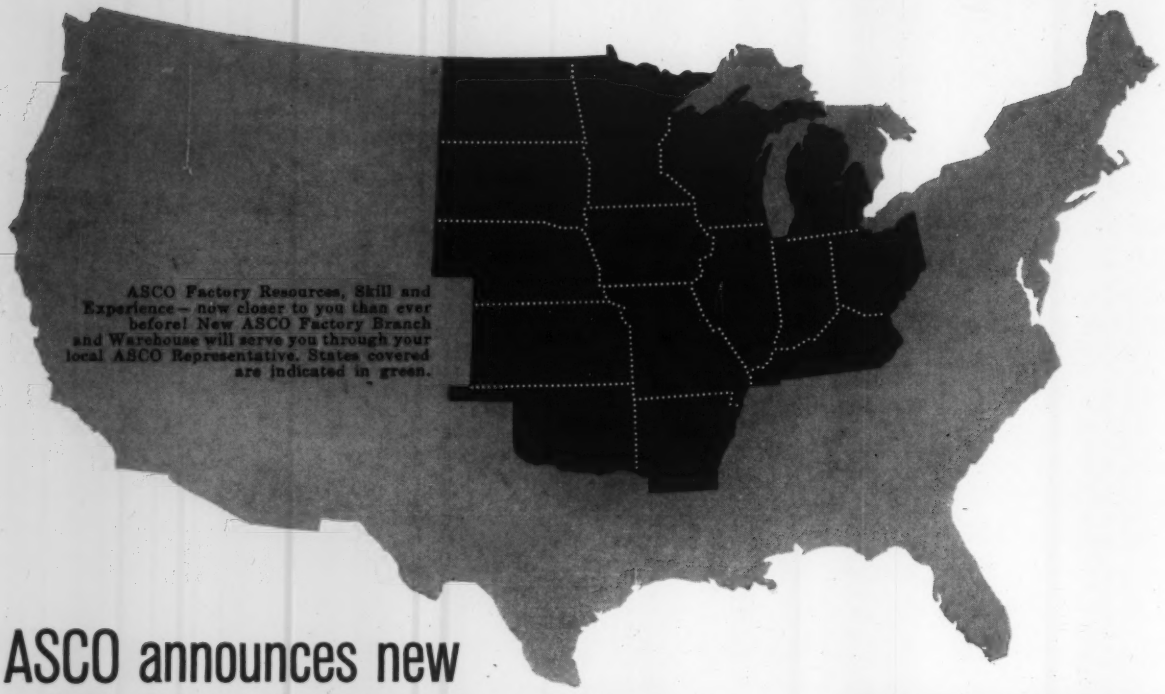

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CHICAGO FACTORY BRANCH and WAREHOUSE!

Full-time factory application engineering service and stock delivery on ASCO Solenoid Valves and ASCO Electromagnetic Control

To insure the fastest possible delivery of solenoid valves and electromagnetic control, ASCO has established a new Chicago Factory Branch and Warehouse. The J. R. Ruddock Company now becomes the Chicago branch of the Automatic Switch Company, under the direction of Ray Ruddock, District Manager. This branch will stock substantial quantities of ASCO products to provide off-the-shelf delivery on many standard items. And experienced ASCO Representatives will be devoting their full energies to ASCO customers.

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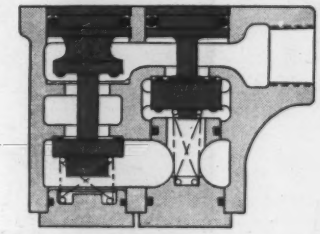
Circle 676 on Page 19

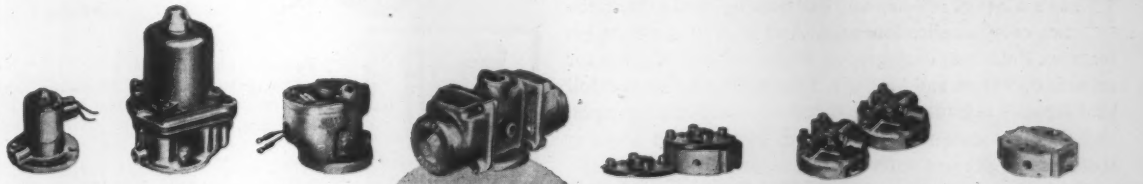
a basic **Ross**
valve building block

4-way inline mounted valve body



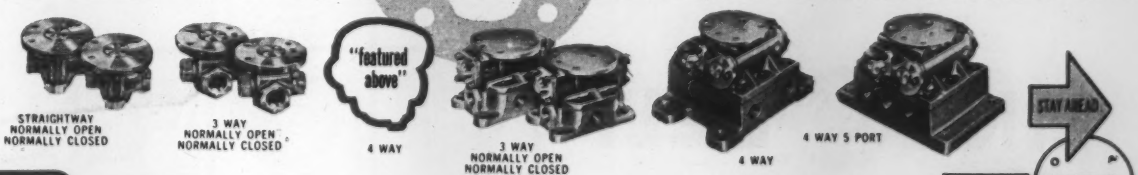
- **Compact—saves space**
- **Ross quality**
- **Costs much less than base mounted 4-way**

Lots of designers use this valve where they must save space. It was designed specifically for compactness! Others use it to save money *without sacrificing* quality—when J.I.C. allows the usage of an inline valve, it meets J.I.C. specs. It's a unit of the Ross Skyline series which features modular construction, so it can be actuated with any Skyline series head. Ross poppet construction means pressure assists the seal, and short poppet travel gives faster response. On most applications it outlives the machine—and frequently doesn't even require maintenance. Write for Bulletin 321.



"every head meets every body at this gasket"

ALL SKYLINE HEADS AND BODIES ARE BUILDING BLOCKS TO GIVE YOU MANY VALVES FROM A FEW HEADS AND BODIES



ROSS OPERATING VALVE COMPANY
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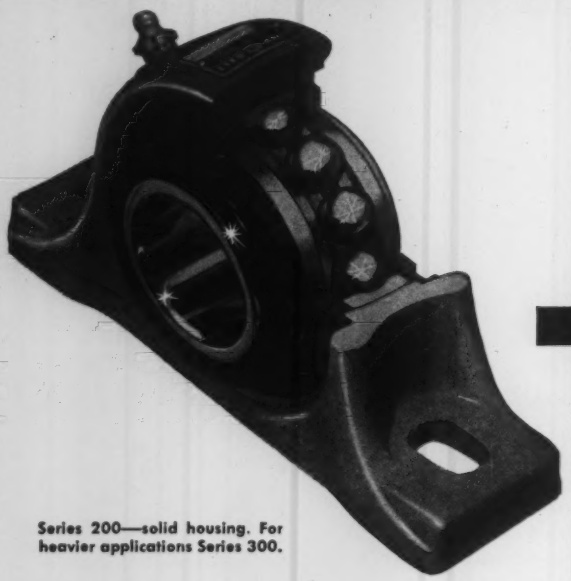
Industry's most complete line . . .

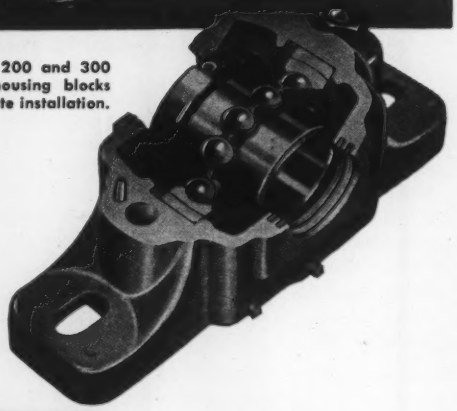
Self-Aligning

ball bearings by Link-Belt



Series 200—solid housing. For heavier applications Series 300.

Series JPS-200 provides low-cost, dependable self-alignment in a pressed-steel housing.

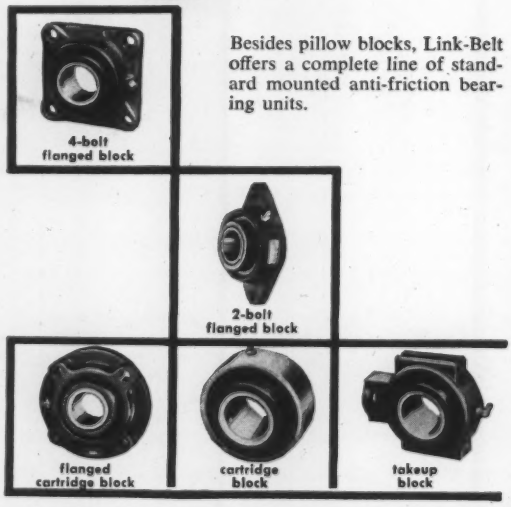


Series 200 and 300 split housing blocks facilitate installation.

HERE's a line of self-aligning ball bearing blocks that satisfies every application need. And look at these design features. Precision, deep-groove, single row ball bearings for smooth operation and long life. Free-rolling action and full load capacity regardless of shaft deflection and misalignment. Self-aligning seals that protect the bearing and aligning surfaces . . . prevent entry of dirt, regardless of alignment.

Simple installation too. Slip bearing on shaft and lock it securely in position with spring locking collar. Slotted bolt holes facilitate mounting on supporting structure.

For complete information on this comprehensive line, contact your nearest Link-Belt office. Ask for Catalog.



Besides pillow blocks, Link-Belt offers a complete line of standard mounted anti-friction bearing units.

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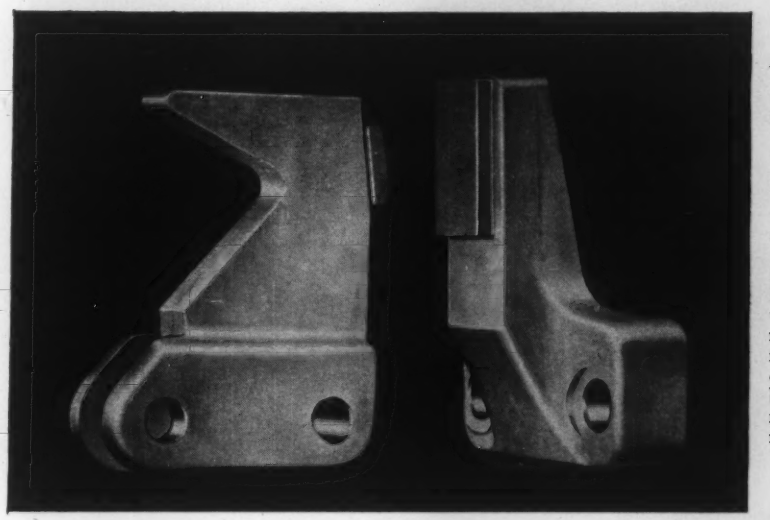
TWICE-WROUGHT METAL

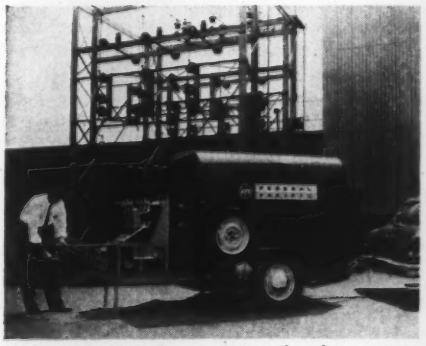
of die-pressed forgings helps Federal Pacific make new air circuit breakers more rugged—cuts machining costs in half



In its new Type DST magnetic air circuit breaker line, Federal Pacific Electric Company, Newark, N. J., builds in dependable operation and long life with parts of outstanding mechanical and adequate electrical properties.

Typical of this attention to detail are the arcing contacts (left). Similar parts previously used had been castings or built-up assemblies. Now the contact bodies are Anaconda Forging Brass-250 die-pressed forgings. The twice-wrought metal is denser, stronger, withstands mechanical shock better—reducing the fatigue factor and producing longer service life. The contacts also have higher conductivity. And best of all, their consistent dimensional accuracy and smooth finish cut machining costs in half.

RIGHT: Movable arcing contact assemblies at the left and the stationary arcing contact assemblies at the right in a 5-kv Federal Pacific Type DST air circuit breaker. They have a momentary current-carrying capacity of 60,000 amperes. Contact tips of tungsten alloy are silver-soldered to the forgings. These are two of several areas where Federal Pacific uses the superior physical properties of Anaconda die-pressed forgings to help provide dependable operation and long service life in its line of metal-clad switchgear.



Federal Pacific takes its circuit breakers out to industrial and electric utility customers. Here a representative sets up a demonstration of a 5-kv, 1,200-amp breaker in the field.

IT IS often easier than you think to achieve high quality and performance while simplifying fabrication and cutting over-all costs. American Brass technical specialists are constantly working with designers, production engineers and buyers, helping them meet their joint requirements—through the use of such Anaconda mill products as die-pressed forgings, extruded shapes, special-shape tubes. For this kind of practical help, see your American Brass representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Toronto 14, Ontario. 8044

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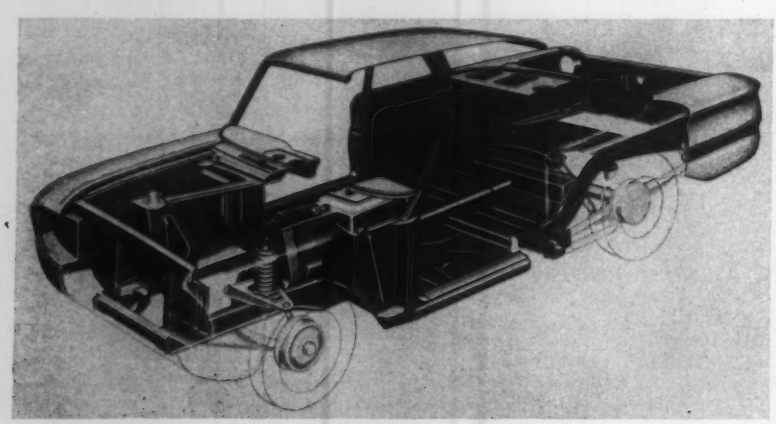
Circle 406 on Page 19

Ford's Falcon

. . . "engineering solution to an economic problem."

DETROIT—Probably the greatest engineering effort this side of Canaveral is wrapped up in the launching of Detroit's three small cars. Ford's Falcon, first of the three to appear, is fairly representative of the industry's small-car thinking.

The Falcon, according to Ford's top management, is "an engineering solution to an economic problem." The problem, of course, is the foreign import, built in a notoriously low-cost atmosphere. In Ford's case the problem was further compounded by extensive market studies which gave this final picture of what the public wanted in an "economy" car: A well styled, good performing, six passenger vehicle; one that would undercut all standard U. S. cars and at least equal the imports in initial cost, fuel consumption, and potential maintenance costs.



Unitized body was a must for Falcon to minimize weight and costs. Heavily galvanized steel, developed by Ford, protects lower sections from rust and corrosion.

Ford's engineering staff claims to have solved the problem by "design simplification unprecedented in the industry."

Starting with Falcon's projected selling price, Ford engineers translated money into weight. Since their final product weighs ¾ ton less than the average '59 Ford—2366 lb versus 3758 lb—this would indicate a strong measure of success in the project.

The first big weight cut is in the engine; it weighs 345 lb ready to run, versus 525 lb for last year's six. The engine also represents some new techniques in foundry art—head and manifold are cast as an integral unit. Pistons, flywheel housing, and transmission extension are aluminum.

A unitized body is the other big reducing item, and from here on, pounds were sweated off in small increments, and designs simplified wherever possible. Examples: The bottom of the trunk is the top of the gas tank, for a net savings of 6 lb in weight. Doors are much thinner than on conventional Fords,

Circle 407 on Page 19→

... Fluid Power news

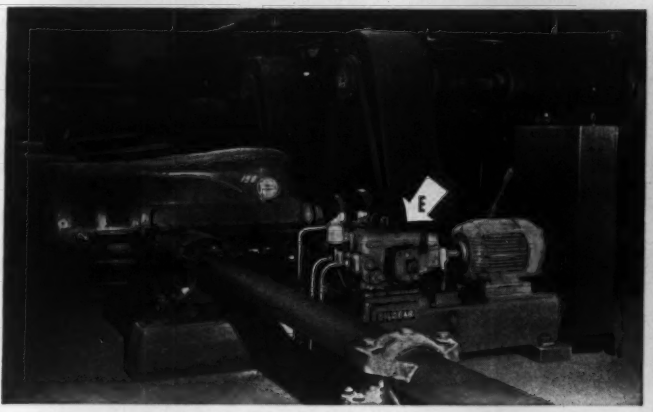
REPORT No. 12,104 OILGEAR SOLVES SPEED CONTROL PROBLEM

From Oilgear Application-Engineering Files

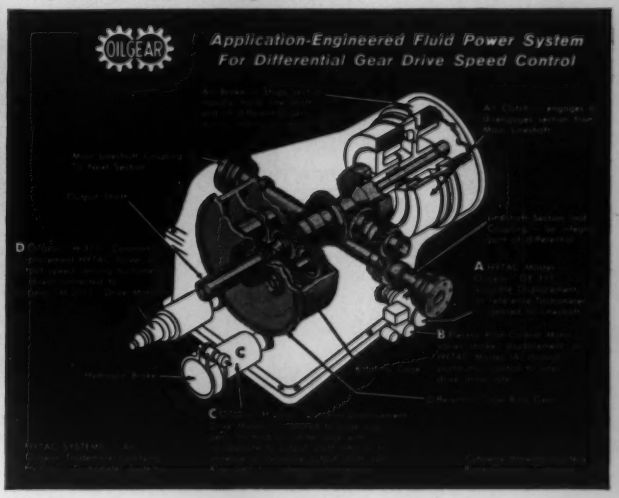
HOW HYTAC SYSTEMS CONTROL DIFFERENTIAL DRIVE SPEEDS ON NEW 190" PAPER MACHINE

USER: *Sonoco Products Company, Hartsville, South Carolina*
BUILDER: *The Black-Clawson Company, Inc., Paper Machine Division, Watertown, New York*

DATA: To design and build a differential-type drive, Black-Clawson engineers outlined the following over-all requirements: 1. To be rugged, simple, and have easily replaceable parts. 2. Speed variation device to control sizes from 150 to 1200 hp, and be capable of performing additional functions — inching, reversing, and slack take-up. 3. Device must maintain synchronous speed regardless of load or temperature changes. 4. Complete drive must be compact, clean design • After solution of gear mechanism problems, the following additional requirements were outlined for the speed variation system: 1. Simple, remote, section control panels, with all controls interlocked. 2. Draw range of at least ±4½%, precisely variable. 3. Must be capable of 24-hour continuous drive service with an absolute minimum of maintenance. 4. Would prefer one source, one responsibility for entire control system. (Mechanical, electrical, and hydraulic systems were investigated.)



A portion of Sonoco Products Company's new "Mr. Mac" — 190" (170" trim) Black-Clawson paper machine designed to produce 9-pt., semi-chemical corrugating board at speeds up to 1500 fpm. "Mr. Mac" is the first paper machine to be fully equipped with differential gear drives on which speed is hydraulically controlled and operated. Three of these new Oilgear Fluid Power Controlled, Black-Clawson differentials are shown above with one of the accompanying Oilgear "Power-Paks" clearly visible. These drives are used on the couch roll, first press, second press, first dryer section, breaker stack, second dryer section, calendar stack, and "autoflyte" reel . . . a total of 8 drives—5 rated at 150 hp, 3 rated at 300 hp.



SOLUTION: Application-Engineered *HYTAC SYSTEMS* arranged through teamwork between Oilgear and Black-Clawson engineers throughout the stages of design, testing, application, and actual installation.

Black-Clawson states — *"operating characteristics highly important to any papermaking machine are obtained through a unique hydraulic motor differential cage drive and a HYTAC SYSTEM (hydraulic tachometer feedback control arrangement). Significant features of this HYTAC drive are: 1. Machine sections can be inched or reversed with line shaft running or down. 2. No helper motors needed — no belts or chain drives involved. 3. Accurate speed regulation. 4. Precision draw control for all applications — 9% draw range. 5. HYTAC SYSTEM maintains speed regardless of load or temperature changes. 6. Hydraulic mechanism and control panels can be located remotely from drives. 7. Complete drive control interlocked. 8. Load on machine sections indicated by pressure gages on drive. 9. Compact, durable construction. 10. Absolute minimum of maintenance required."* The reasoning that led to selection of HYTAC SYSTEMS has also been clearly stated by Black-Clawson engineers, as follows: *"Mechanical drives had many serious drawbacks, such as horsepower limitations and the inability to perform the desired functions. Choice between electric or hydraulic drive proved more difficult . . . necessity that electronic controls circuits would be required to maintain accuracy, and the larger size of the driving units were the deciding factors in favor of the hydraulic drive. To determine size, an analysis was made . . . here again hydraulic drive proved its superiority, since the drive motor could be driven in both directions. Tests proved that the drive was even more accurate than our original expectations . . . regulation between zero and rated load was only ±0.005%. Under conditions of constant load and speed, a variation of ±0.002% could also occur . . . when added together, maximum regulation is ±0.007%."*

HOW IT WORKS: Fluid from lineshaft-driven master tach (A) gives differential drive speed command to control on Oilgear "DRX-2011" two-way, variable displacement pump (E), indicated in photo, left, of Oilgear "Power-Pak" installation. Slave tach (D) feeds back a flow signal proportional to actual differential drive speed. When main lineshaft speed increases or decreases, fluid flow from Master Tach (A) automatically increases or decreases correspondingly to command differential drive to follow lineshaft speed change. Through local or remote pushbutton stations connected to electric pilot motor (B) on Master Tach (A), operator can increase or decrease speed of each section infinitely up to 9% of prevailing lineshaft speed. When differential cage is rotated with, or in same direction as the output shaft by motors (C), output shaft speed is increased. If cage is rotated in the opposite direction by motors (C), output shaft speed is decreased. All factors, such as change in load or temperature, are automatically compensated by these HYTAC SYSTEMS to maintain exact, set degree of section synchronization with lineshaft at all times.

Accurate synchronization of multiple, tandem operations; combining separate operations to handle webs or sheets — soft, fragile at one point — strong at another; or continuous webs when tension affects quality . . . all need more than conventional drives and controls . . . they need the precision of HYTAC SYSTEMS, or other Oilgear "Any-Speed" drives and controls!

For practical solutions to YOUR linear or rotary Controlled-Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

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giving more inside width. They also contain 21 fewer parts.

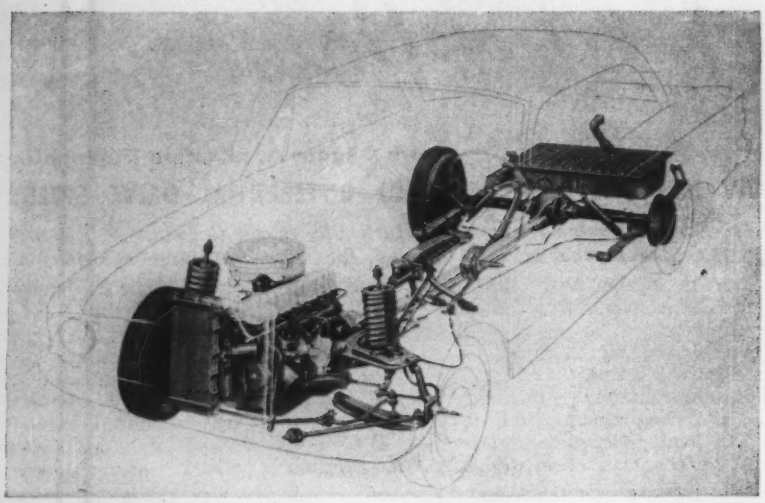
Since Ford's market study called for a big economy car, interior dimensions of the Falcon differ little from the Ford. Headroom is the same, legroom differs by an inch, and hiproom is less in the Falcon by about 3 in.

Falcon's fuel consumption is touted at 30 mpg, and maintenance costs predicted to be very low. In fact, Ford officials claim that the Falcon, like the Model T, is definitely in the backyard mechanic's league. It even has bolt-on fenders.

The first Falcons produced will be two and four-door sedans, with a station wagon scheduled for next spring. While the outside of all models will look the same, the inside can be plain or fancy, depending on the options—automatic transmission, radio, padded instrument panel, and deluxe trim.

Falcon-Ford Size Comparison

Dimensions	Falcon 2-Dr and 4-Dr Sedans	'59 Ford 300 2-Dr Sedan
Length (in.)	181.1	208.0
Height, loaded (in.)	54.5	56.0
Width (in.)	70.0	76.8
Wheelbase (in.)	109.5	118.0
Curb weight (lb)	2366	3570
Tread, front (in.)	55.0	59.0
Tread, rear (in.)	54.5	56.4



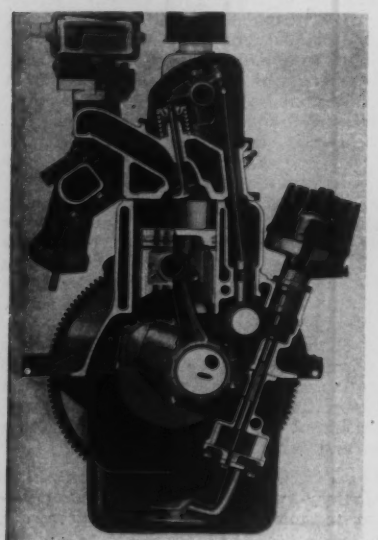
Falcon Fine Points

Much of the design is based on proven component applications patterned after the conventional Ford:

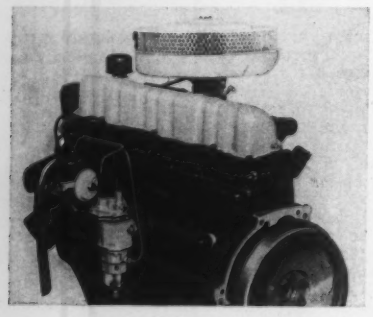
- Front suspension is somewhat different than Ford. Spring and shock absorber are mounted from the upper arm to a tower in the sheet metal of the body. The lower arm and stabilizing strut form the so called "A" frame and serve to guide the lower part of the spindle. The stabilizing strut also cushions fore-and-aft thrust. Ball joints are of standard steel construction—similar to those on Fords.
- Steering system is of conventional design, using recirculating balls. Concentric steering column is used (no separate shift column). Brake and clutch pedals are overhung.
- Brakes are 9 in. in diameter and contain 30 fewer pieces than present duo-servo brakes.
- Standard transmission is a 3-speed synchromesh. Automatic transmission is the 2-speed Fordomatic with 10½-in. converter.
- Rear suspension is the Hotchkiss type using 5-leaf rear springs.
- Tires are low-profile 6.00 x 13.

Cast-Iron Engine . . . Up Front!

Since engine material, cooling, and location are touchy subjects this year, Ford has carefully documented its reasons for being conventional:



Engine in front: Space between the front wheels, which have to turn, is just right for an engine, too small for a trunk. Also, weight-distribution is generally complicated by placing the engine in the rear—particularly in a car the size of the Falcon. Looking at the imports, Ford points out that none of the rear-engine models weigh more than 1900 lb. Fiat, for example, puts the engine in front in all models weighing more than 1800 lb.



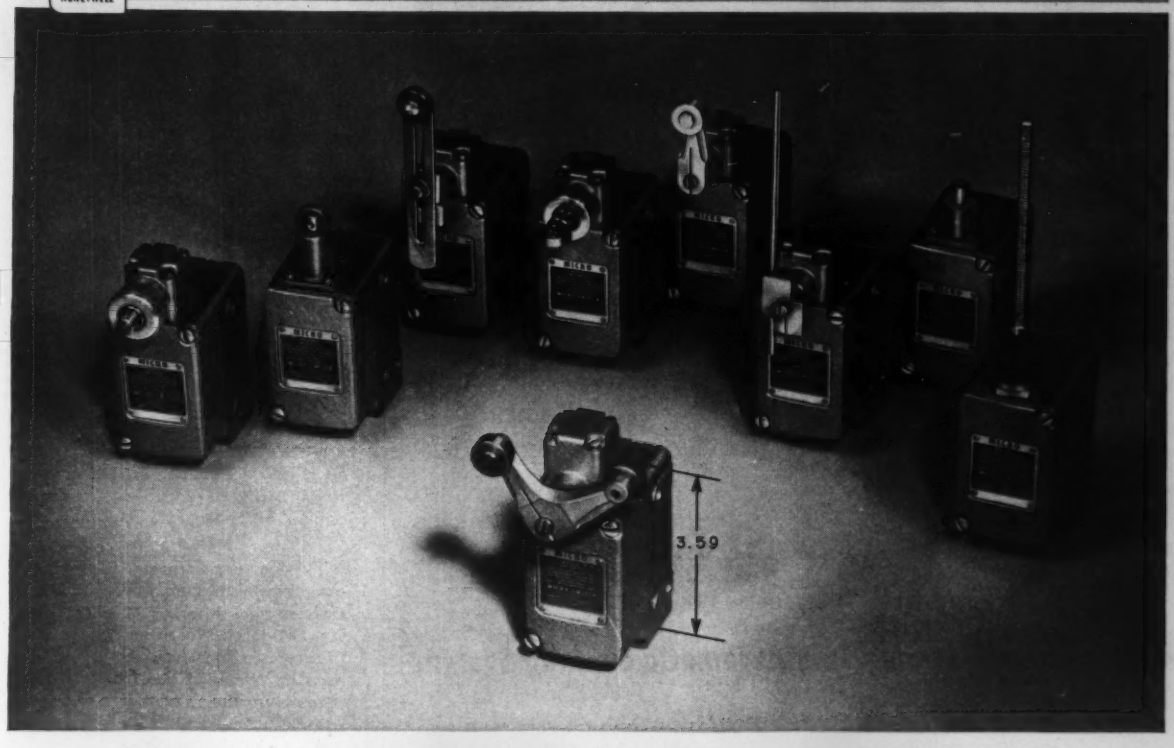
Engine Specifications

Type	six-in-line, OHV
Bore & Stroke (in.)	3.5 x 2.5
Displacement (cu in.)	144.3
Compression ratio	8.7 to 1
Power, max (bhp)	90 @ 4200
Torque, max (lb-ft)	138 @ 2000
Crankcase capacity (qt)	4-5

Cast-iron block: According to Ford engineers, an aluminum block would have cut no more than 50 lb from the weight of the Falcon's engine. Because the engine is in front, this was not considered critical, especially since the use of aluminum would have entailed costly cylinder liners.

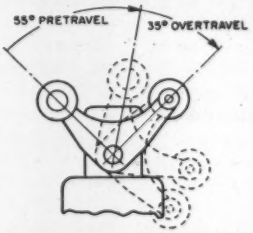
Water Cooled: This was natural after the first two decisions, but stands on some merits of its own. An air-cooled engine needs an extra-large fan—noisy and a drain on power. Lack of a water jacket also makes for a noisier engine. And while an air-cooled powerplant needs no antifreeze, it also creates a problem in heating the car. The solution is usually a gasoline heater, which adds to initial cost and cuts down fuel economy (by 10 per cent in winter, according to Ford).

H HONEYWELL MICRO SWITCH Precision Switches



New "Plug-in Limit" switch ... now there are nine

Here is a new "Plug-in Limit" switch with yoke actuator—the ninth in the famous "200LS" Series. The yoke is adjustable to any position on the shaft through 360°, and the operating head mounts in any of four positions. The new 206LS1 is a maintained contact switch.



"200LS" Series switches have found ready acceptance as limit switches for control of lathe carriages, grinders, table feeds, drilling and tapping equipment, automated machinery, etc.

"Plug-in Limit" switches plug into the terminal enclosure like a radio tube and can be replaced in seconds, practically eliminating costly downtime. They are rugged, reliable, and completely sealed against oil, water, dirt and dust.

Contact arrangement is two-circuit double-throw.

Electrical rating is: 10 amps, 120, 240, 480 vac; ½ hp, 120 vac; 1 hp, 240 vac; 0.8 amp, 115 vdc; 0.4 amp, 230 vdc; 0.1 amp, 550 vdc. Pilot duty rating is 600 vac max. Meets NEMA Industrial Control standards.

PULL OUT

For details of the "200LS" Series, write or call the MICRO SWITCH *branch office or authorized distributor near you. Consult the Yellow Pages.*

MICRO SWITCH ... FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

H HONEYWELL **Honeywell**
MICRO SWITCH Precision Switches

Circle 408 on Page 19

These four units form the new data processing system:
1. High-speed check sorter
2. Computer (housed in cabinet)
3. Record processor
4. Control console

Computer and Memory Join Automatic Banking System

New Equipment Takes On Bookkeeping, Accounting Jobs

DETROIT—Computer-driven banking equipment that handles and proves checks, keeps books, prepares bank records and customer statements, and provides accounting and statistical reports is the latest Burroughs Corp. electronic bank data processing system. This system is so flexible that it will handle checking and savings accounts, installment loans, mortgages, and other accounting and bookkeeping operations simultaneously.

It is made up of four units. The first is the world's fastest check sorter (MD, April 16, 1959, p. 8). The second unit is a completely transistorized computer with a magnetic-core memory. The computer processes information read by the sorter and sends it on to the record processor. Here, items are automatically entered on statement and ledger forms, are proved, and the customer's current balance is computed and printed. The remaining unit is a control console. In addition to light panels, program selector knobs, and other standard console controls and indicators, the console contains a keyboard to permit entry of unusual items and special orders. Instructions can be given to reject checks, to stop payment of checks, or to do other unusual jobs.

Individual account information, printed in standard type on the face of each ledger, is stored electronically in two narrow magnetic stripes on the back of the ledger form. This enables the machine to read the ledger and carry out special instructions stored in the stripes.

Programs are stored on long-lasting Mylar plastic tapes and are installed on tape readers. The system may use up to 12 tape readers, permitting more than 2500 programming instructions at any one time.

Topics

Hi-fi joins the Navy to help train Sonar operators. Tape recordings of submarine hunter-killer squadron activities are being used in a new training device to teach the difference between blips denoting actual submarines and false signals produced by schools of fish, underwater mountain peaks, wrecked ships, or masses of plankton.

• • •

Life ends at 40 for wings of the F-104 Starfighter. In a 3½-year test program, Lockheed engineers simulated 2-hour combat flights, using hydraulic jacks to subject the wings to the same bending and twisting they would encounter in all phases of flight, both subsonic and supersonic. The first structural failure occurred after service equal to 40 years' use—10,793 "flights," involving over a million flight-like load applications.

• • •

TV does not harm a child's vision, according to an ophthalmologist at the University of Michigan Medical Center. Dr. John W. Henderson reports, "There is no evidence to show that excessive television viewing does more than injure the mind."

• • •

Price of tires drops 25 per cent—for antique models. Firestone's new tires for old cars will henceforth carry less modern price tags. The company makes authentic reproductions of 1908 nonskid tires. These have a tread pattern composed of letters set at an angle to repeat the phrase "Non-Skid."

• • •

Ivan eyes Detroit's answer to the troika and finds it most appealing. At the American National Exhibition held in Moscow, the automobile section was the favorite display. Second in popularity was color television.

• • •

A real clever doll, recently patented, can write. It holds a pad in one hand and a writing instrument in the other, and when a crank is turned, a series of rods and cams in the doll's innards causes it to write "ma." The mechanism can be altered to provide for tracing some other short word or a picture, and the doll can be either right or left-handed.

• • •

Wholesale reveille is the business of an automatic awakening system proposed for use in hotels. Instead of individual calls to each guest, telephones of everyone who left a call for a certain time would ring simultaneously. The hotel switchboard would be set up for this rousing operation during the wee hours.

N/D CASE HISTORIES

Photo: courtesy Ready Tool Company

N/D Bearing Design Helps Live Center Maker Achieve Accuracy of .000050"!

CUSTOMER PROBLEM:

Live center maker requires bearing design that will help achieve . . . and maintain . . . live center accuracy of .000050", under combination radial and thrust loads.

SOLUTION:

After thorough evaluation of the problem, New Departure recommended N/D pre-loaded, duplex ball bearings. Extensive testing proved these super-precise ball bearings resisted combination radial and thrust loads with minimum deflection. The N/D ball bearings, with medium and high contact angles, are mounted duplex and positively clamped together to assure the optimum, pre-determined preload condition. As work expansion increases the thrust load, radial centering becomes more rigid and accuracy is precisely maintained . . . to less than .000050" total indicator run-out!

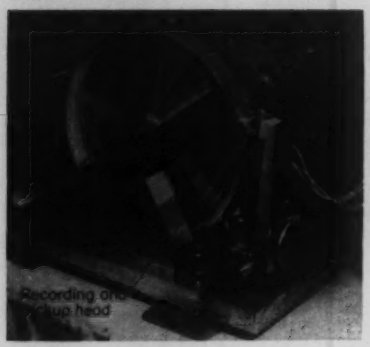
When you're working on new designs that call for high precision ball bearings, why not call on New Departure? New Departure's consistent precision is your assurance of the ultimate in accuracy for your design. For more information, call the New Departure Sales Engineer in your area or write Dept. Q-9.

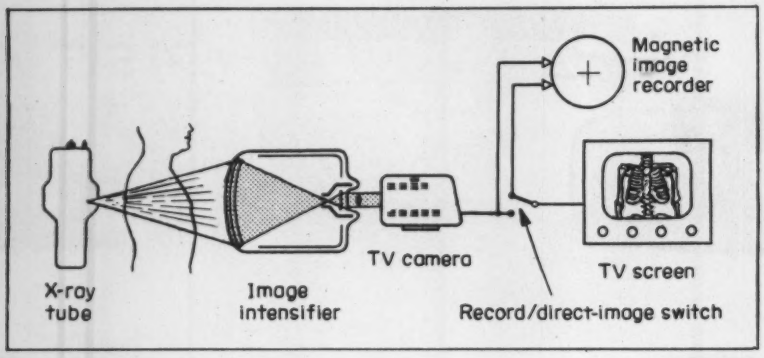
Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL





Magnetic Memory Stores X-Ray Images

Memory wheel rotates at 50 rps to record up to 10 x-ray images. Developed by NV Philips' Gloeilampenfabrieken, Eindhoven, Holland, and demonstrated at the recent International Congress of Radiology in Munich, Germany, the cylindrical surface of the ten-track 12-in. wheel is coated with a magnetic recording substance. When used in medical radiology, patient exposure time is reduced and diagnosis is speeded up (recording is available without developing a photographic plate). A combination recording and pickup head produces, on a single track, a linear recording of a 300-line x-ray image obtained through a conventional image intensifier and TV camera. Aerodynamic shape of the head helps it maintain balance between centrifugal air pressure and centripetal force of an adjustable spring. A separate erasing head is used. A locking circuit in the record amplifier limits exposure time to 1/50 sec (to correspond to the 50 rps speed) so that scanning frequency corresponds to that of a European TV signal.

Basic-Tool Line Designed for Electrospark Machining

33 Different Tools From 16 "Building Blocks"

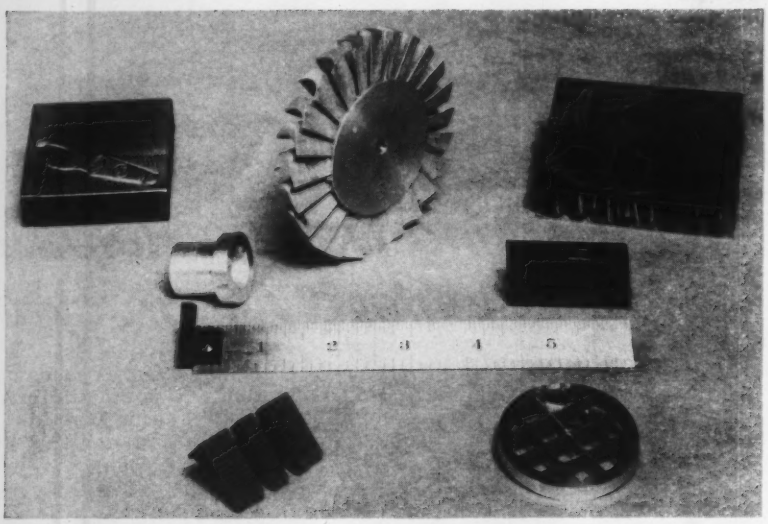
CINCINNATI — Electrospark machining—that process by which material is spark eroded from a surface much like automotive spark plugs become eroded—has, in its decade or so of industrial acceptance, been plagued by the term "specialty process." While the term is slowly wearing off, one drawback to more general use has been lack of a standard electrospark machine-tool line.

Such a machine-tool line has now been designed by Cincinnati Milling Machine Co. Based on years of development and research work, these new tools have become sophisticated at machining the so-called unmachinable die materials, at producing odd-shaped holes, and at machining without distortion, burr formation, and heating.

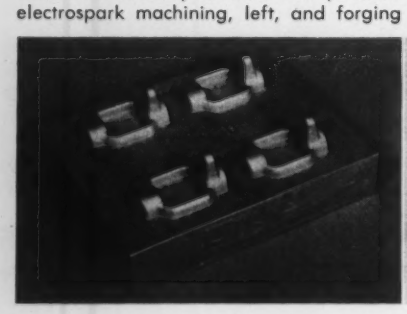
Nuclei of the line are 16 building block units from which 33 separate machine tools can be constructed. These building blocks consist of two bases, two slides, four workheads, four base-tank units, and four power supplies.

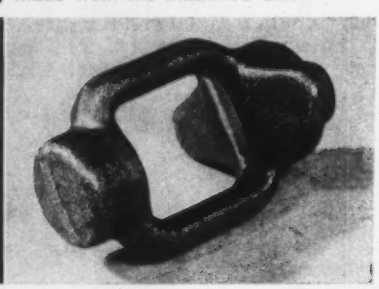
Workheads and base-tank units are entirely interchangeable. Workheads include:

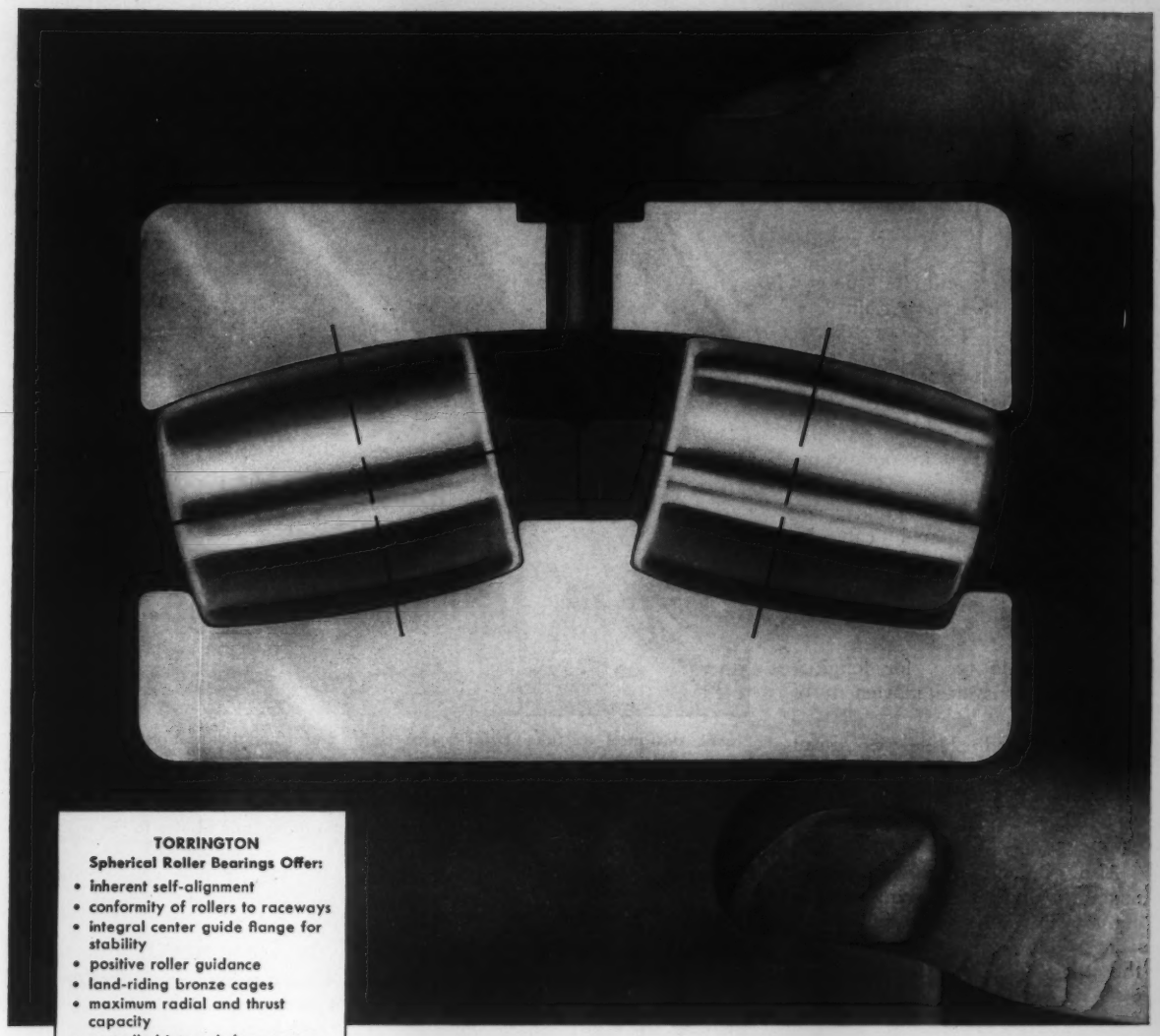
- Nonrotating type, in which



Typical work turned out by the electrospark machining process in which no tool ever actually touches the product (above). Below—diecast electrode for electrospark machining, left, and forging made from the machined die.

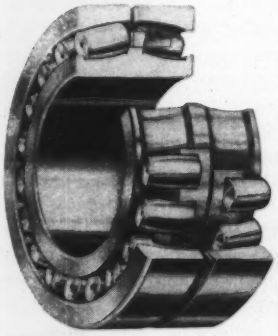






TORRINGTON
Spherical Roller Bearings Offer:

- inherent self-alignment
- conformity of rollers to raceways
- integral center guide flange for stability
- positive roller guidance
- land-riding bronze cages
- maximum radial and thrust capacity
- controlled internal clearance
- electronically selected rollers
- even load distribution
- long, dependable service life



Send for new Torrington
Spherical Roller Bearing Catalog #258.

Shaped for Stability!

The asymmetrical shape of each roller in Torrington Spherical Roller Bearings contributes directly to operating stability and long service life.

The maximum roller diameter is not at the center of the roller. Located towards the center flange, it insures geometric positioning of the roller for positive guidance with free rolling action.

The roller shape also approaches that of a tapered roller. Lines extended from the roller-to-race contact zone converge at the roller and bearing axes. This approach to true conical rolling action further assures stability.

These are two more reasons why Torrington Spherical Roller Bearings operate cooler, quieter and with greater stability. For the ultimate in bearing performance and service life, always specify *Torrington* Spherical Roller Bearings. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

Every Basic Type of Anti-friction Bearing

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

Circle 410 on Page 19

shapes are produced by vertical feed of a formed electrode.

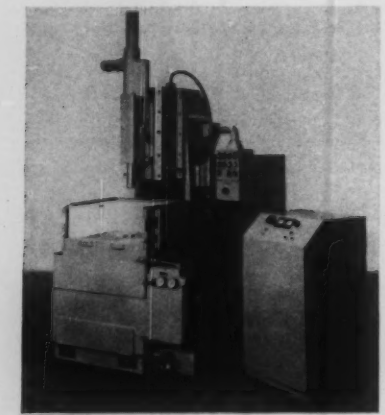
- Rotating type, for improved machining and increased stock removal rate.
- Universal type, for eccentric or planetary rotation of the spindle.
- Ram type, for extra-large plunging cuts.

Because workpiece and electrode are bathed in a dielectric fluid (to quickly quench sparks and wash away debris), electrospark machining is done within a tank. The base-tank units include:

- Solid type, for easily clamped workpieces produced in production quantities.
- Open-front type, for greater accessibility; front panel can be lowered.
- Disappearing type, for extremely large parts; tank recedes into bed of machine.
- Moving-table type, for longitudinal and transverse movement of clamped parts.

Fixed and adjustable workhead slides, and 4 power supplies ranging from 20 to 100 amp ratings round out the interchangeable equipment.

Also available are two grinding machines and one diesinking machine. The diesinker is built with a larger base and column size than the others. Other parts of the "non-interchangeables" are standard components.



One possible combination of components. This machine is made from the standard base and column, the dropfront tank, ram workhead, and movable slide.

Space-Age Plastic Ignores Heat and Temperature

Plastic designed to take 1000 F is a reinforced phenolic laminate. Developed by Riverside Plastics Corp., Hicksville, N. Y., it meets the missile industry's need for a low-dielectric, structurally strong material able to withstand heat and temperature. Samples of the synthetic, originally at room temperature, were thrust into an electric oven (above) to demonstrate the material's ability to resist thermal shock. Though oven temperature was 1000 F, the samples did not blister or delaminate. Another advantage—because of low thermal conductivity, the plastic is an excellent heat insulator.

Navy Sets Up Bureau of Weapons

WASHINGTON—In a move to keep space-age administrative functions in step with rapid technological developments, the Navy has merged two old and important Bureaus—Ordnance and Aeronautics—into the single, streamlined Bureau of Weapons. The new Bureau assumed command on September 1.

First objective of the merger is to provide a more effective organization for the development and procurement of Naval weapons and weapon systems, plus integrating the many different phases of modern weapon systems. This gives the Navy a unified approach to the development of weapon systems rather than two parallel approaches which, particularly in the missile field, have been common under the two related bureaus.

Under a chief and deputy chief, the new organization places strong emphasis on program management to insure positive direction to the research, development, production, and support of weapons. There will also be an administrative group headed by an Assistant Chief for Program Management. This group will have two major functions—one covering planning and another having executive authority for managing programs categorized as anti-submarine warfare, air defense, strike warfare, support and logistics, etc. Four operating areas, each under the direction of an Assistant Chief, will direct: 1. Research; development; test and evaluation. 2. Procurement and production. 3. Fleet readiness. 4. Field support.

Of 350 field stations and establishments under the administration of either Bureau of Ordnance or Bureau of Aeronautics, none is expected to undergo immediate change.

DRAFTING TRENDS

Shock-Free Chain

New chain link that absorbs shock and impact on lifting, towing, and load-binding chains reduces breakdowns and increases factor of safety. Developed by Brandon Equipment Co., Chicago, the device combines cushioning properties of rubber with strength of alloy steel. The rubber is permanently bonded to the chain (with the links in contracted position) under heat and pressure. The design is such that rubber is under shear, compression, and tension in different sections when a load is applied.

Numerically Controlled Tools Endorsed by Air Force

DAYTON, OHIO—Advantages of numerically controlled machine tools are being spelled out these days by the Air Materiel Command to prime contractors of high-speed aircraft. According to AMC, better close-tolerance work is possible with numerical-control methods and precision machining on the new superhard aircraft metals is much enhanced.

The machine tool that is "married to a computer" to provide an almost entirely automated process is reportedly the proper tool to fabricate parts that may be critical at Mach 3 and greater speeds. Air Force feels so strongly on this matter that spokesmen promise: "Facility expansions and modernizations financed by the Air Force will be critically reviewed to assure procurements of numerically controlled tools wherever suitable."

Whether you are filing a few hundred or hundreds of thousands of drawings, you will find easily expanded and easily altered Hamilton-Pack Inter-Lock units give you both the accessibility and the flexibility you need for efficient filing.

Ingenious new way to solve drawing storage problem

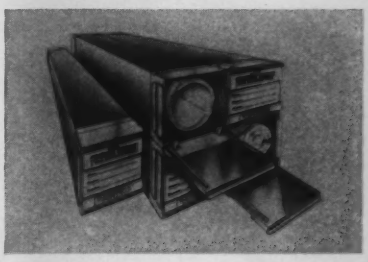
Finding a place to store drawings is becoming a tougher and tougher job every year.

One hope toward finding unused space for storage seems to lie in using what is now thought of as "dead space" . . . the area between the top of present filing systems and the ceiling . . . between files . . . under tables and many other nooks and crannies where it would not be practical to put a full sized filing unit.

These are some of the reasons why much interest is currently being shown in the newly introduced Hamilton-Pack Inter-Lock filing system.

The basic unit of a Hamilton-Pack file is a cylindrical air-tight, dust-tight, light-tight compartment in which one drawing, or many drawings rolled together, or four separate rolls of drawings may be stored. The door of each unit contains a card serving as an index for the drawings inside. Color coded index cards, specially made for the Hamilton-Pack file, can be slipped into the door slot to show the current status of a drawing.

These compartments dovetail into each other and are locked into position by metal key pins that simply



drop into position, thus making stacks of files into solid units. The stacks are easily altered, permitting great flexibility in arrangements of file space.

Although especially appropriate for storage of inactive or obsolete drawings (with a complete project of up to 30 tracings group-rolled into one compartment), Hamilton-Pack files are also convenient for current work. The funnel-shaped openings provide fingertip removal or insertion of drawings without damaging them. Excellent protection is assured in the crush-proof, fire-resistant compartments.

For more information on Hamilton-Pack Inter-Lock filing systems, write today to Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

Circle 411 on Page 19

THIS MUCH MORE in '59

Expansion was not the order of the day during the past year, but it was in this period that the growing sales of "Double Diamonds" required the addition of 60% more manufacturing space. Hence, we now enter the more promising future with better and more facilities to serve as your "gear department" or to fill your gear orders with "Double Diamond" Gears that are built *to produce low installed cost... to serve economically and dependably on the job for which you buy them... and to do credit to your product and your reputation.*

May we send you this catalog of the gear types in which we specialize: helical gears, flywheel starter gears, straight bevel gears, straight spur gears, angular bevel gears, hypoid bevel gears, gear assemblies, zerol* bevel gears, spiral bevel gears, and spline shafts?

*Reg. U. S. Pat. Off.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

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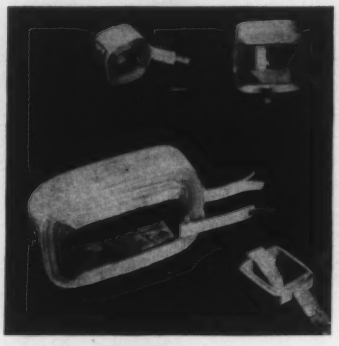
Circle 413 on Page 19

NEWS TRENDS

new fields for foil coils



More than 150 coil manufacturers are testing and evaluating a wide selection of aluminum strip-wound coils in a year-old development program initiated by Aluminum Co. of America. Results of the program will soon be summarized by Alcoa in a detailed analysis of mechanical and electrical characteristics of strip coils. The report will also include a roundup of recent research on coatings and winding techniques. According to Alcoa, there is already clear indication that aluminum strip will make sizable new inroads in the field. At least five manufacturers are now ready to custom wind any kind of strip coil, large or small, and many new types of coils are going into regular production.

plug-in cities

Development of a three-cable electric-power circuit able to supply a city the size of Toledo (300,000 population) is underway at Cornell University. Sponsors of the project, Edison Electric Institute and Association of Edison Illuminating Cos., explain that most metropolitan power lines will be woefully inadequate within ten years and say that by 1965 they expect to have single power lines with a service rating of 350,000 volts and 500 million volt-amperes.

tire of the future: one ply, steel cords

Tires that offer truckers 10 per cent more miles per gallon, wear 1½ to 2 times as long as conventional tires, give 30 per cent more deflection for a softer ride, and run 100 F cooler than conventional tires may be the tire of the future says Goodyear. The new tires—already being produced and sold in limited quantities—have a single ply of steel cord running radially from bead to bead, reinforced by three diagonal steel breaker plies. This unique locked-together construction lets the tread roll on the road without the usual wearing and scrubbing movement—there is no pantographic action. Flexing is confined to the tire's buoyant sidewalls, which also adds to vehicle cushioning.

Navy pioneers in thermoelectric hardware

Experimental thermoelectric appliance—a three-in-one air conditioner, space heater and refrigerator-freezer—is being built for the Navy by Westinghouse. It will be the largest and most versatile thermoelectric-powered appliance yet undertaken. The air conditioner alone, a full one-ton unit, represents a capacity 50 times greater than any thermoelectric device built previously. The three components will be designed to operate independently of each other.

light heavyweight

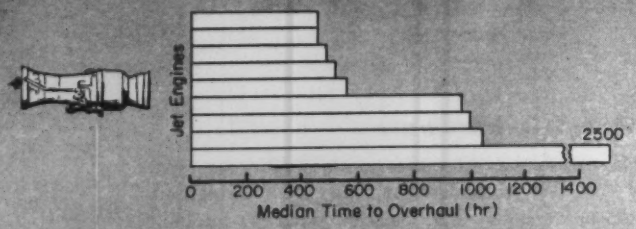
Truck designers are chalking up impressive gains in their continual battle against weight, and careful selection of materials is one of the key reasons. Newest of the heavyweights to get a lean look is GM's new 8000 series which can carry an extra ton of cargo, over previous models, and still stay within the 61,000 lb gross combination weight rating. A valuable 200 lb is saved by powering the truck with GM's new V-6 diesel and another 300 lb by redesigning the frame (it's now made of welded I-beams; SAE 950 steel). The remaining weight was pared off in the cab, an all-aluminum job with a glass-fiber grille. Weight of the cab, less glass and controls, is just 296 lb.

computer by telephone

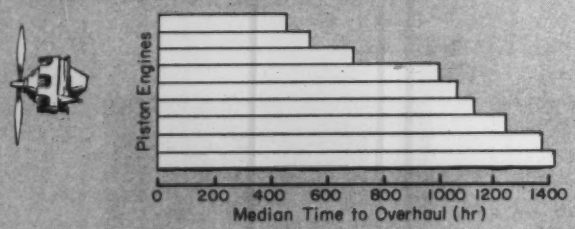
New computer system developed by Daystrom Inc., La Jolla, Calif., takes advantage of existing standard telephone circuits to link computers with remote experimental sites. Key to the system is a special coding device that translates process or test data into digital form for telephone transmission. Large companies with multiple plant and test facilities may thus be able to service all sites from one computer center.

orange line of krypton 86—new length standard?

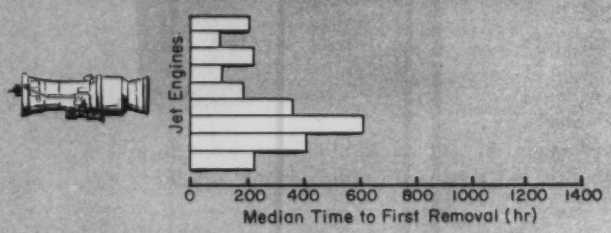
The 1960 International Conference on Weights and Measures will probably sanction a wavelength of light—the orange line of the element Krypton 86—as a new standard of measurement. If so, the wavelength will replace the present-day metal bar as the universal metric standard. National Bureau of Standards is also studying the feasibility of many other new standards in a high-priority effort to keep pace with critical space-age demands.



Median time to overhaul for various jet engines plotted doesn't look significantly different from similar figures for piston engines.



But above figures don't show that the active field-repair program of the Air Force has increased time to first overhaul for these engines.



Jet engines still have to be removed for repair much sooner than piston engines. To increase turbine life, designers must:

- Choose materials with strength, conductivity, heat tolerance, and good damping characteristics.
- Increase factors of safety.
- Avoid stress concentrations.
- Design for unharmonic spacing to avoid resonance.

More important yet, says NASA, is a program of record keeping that gives the grounds for predicting component life, and probability of failure for any part in the engine. Then inspection can spot defective parts and they can be replaced in time.

It's hard to realize the jet age is so young when designers talk blithely of gas-turbine power plants for automobiles, tractors, boats, and electric power generation. Two decades of fiercely competitive military aircraft research are ready to pay off by . . .

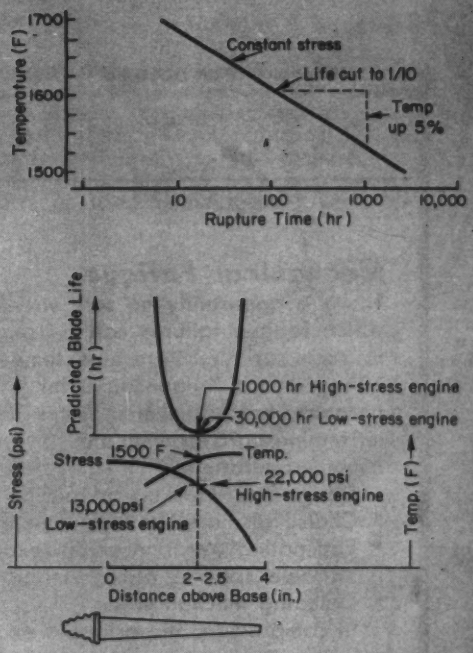
Keeping Turbines Out of Trouble

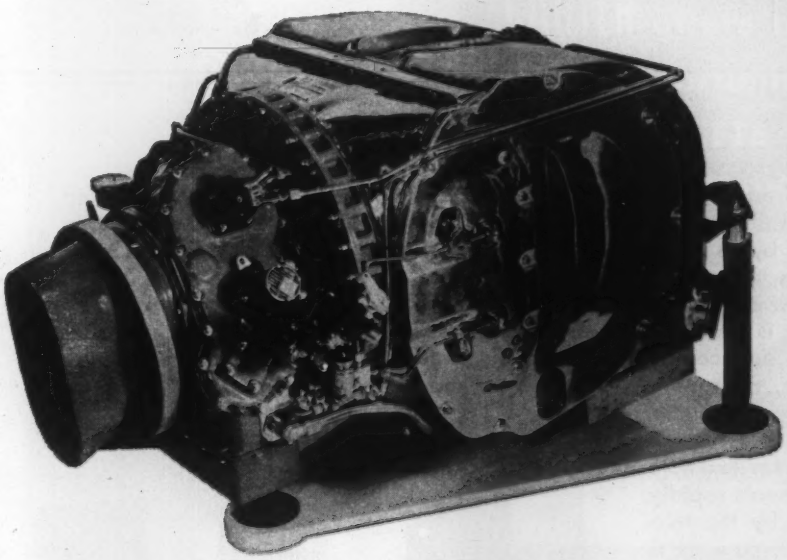
WEAR AND FATIGUE take their tolls even on piston power plants, so limited engine life is not a new concept to airmen. But it takes on new meaning in gas turbines where temperatures run up to 1500 F or more, and rotational speeds are up to 10,000 rpm.

In 1956, The Lewis Research Center under the NACA reported

Stress Rupture

Under enough heat and tensile stress, a specimen elongates and finally breaks. This is stress rupture, the time of which is a function of temperature and load. Temperature's influence is shown by the plot of failure time versus temperature for S-816 alloy. Notice that at a typical jet engine temperature of 1500 F, 5 per cent increase in temperature causes a 90 per cent drop in life. But load is also important. The combination plot of blade stress, temperature, and life shows that the critical point on most blades tends to be about 1/3 to 1/2 its span from the blade root. Accompanying figures show that by designing for half the stress, the designer increases blade life 30 times.





S. S. MANSON, G. M. AULT
Materials and Structures Div.
Lewis Research Center, NASA
Cleveland, Ohio

and

B. PINKEL
Aero Astronautics Dept.
Rand Corp.
Santa Monica, Calif.

on factors affecting reliability of turbojet engines. The report was classified confidential. Recently, it was declassified and subsequent NASA studies have brought it up to date.*

Although some of the failure mechanisms listed are enemies well-known to seasoned designers of jet aircraft, the implications of the over-all story are important to any designer who is planning to convert to gas turbines. Commercial airlines are already alerted to these specialized jet problems.

Running time between repairs has been found by NASA studies to be much shorter for the average jet engine in military service than for the average piston engine. The Air Force has offset the cost and downtime to some extent by a program of field replacement and repair. Knowledge of the probable service of various components would make such a program more effective and reliable.

*S. S. Manson, G. M. Ault, and B. Pinkel —"NASA Research Bearing on Jet Reliability," SAE National Aeronautic Meeting, March 31-April 3, 1959.

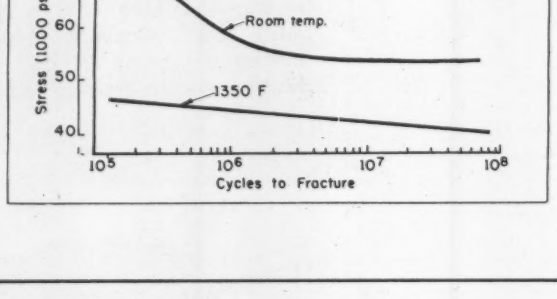
Mechanical Fatigue

There is apparently no safe stress level below which fatigue failures can be guaranteed not to occur at typical turbine temperatures. At 10^8 cycles the fatigue curve for jet-engine temperatures has not leveled in this *SN* plot. Many jet engine parts accumulate 10^7 cycles in a few minutes operation.

Design has attacked fatigue on three fronts:

- Choice of materials with long fatigue life.
- Eliminating resonance—an example is the variable spacing of nozzle blades.
- Damping mechanisms.

In compressors, the principle exciting force is rotating stall—a condition typically found in part-rated speed where compressor blades are hammered by dead air zones that move from blade to blade. Solutions include compressor bleed devices, rotating guide vanes, and twin-spool compressors.

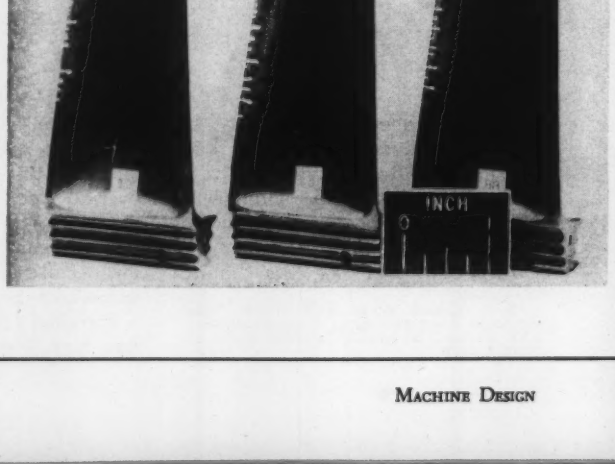


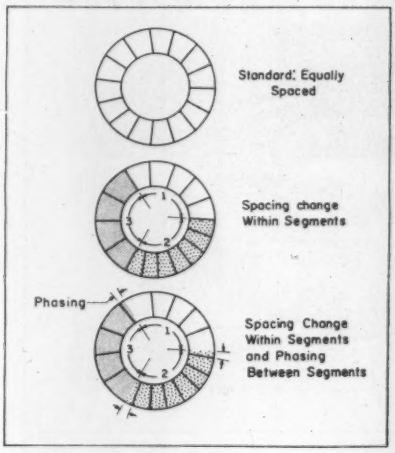
Thermal Stress and Fatigue

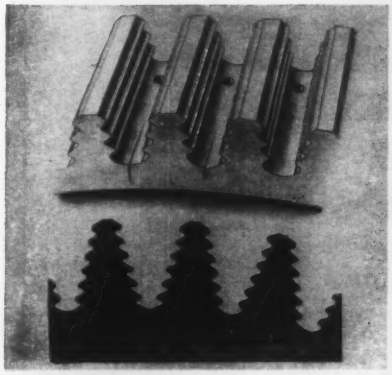
Differential heating of an object frequently induces mechanical stresses. The heated portion tends to expand, but is restrained by its bonds to the cooler portion. Depending on configuration, it may crack or plastic flow may occur to cause a residual stress when it is cooled to ambient temperature. If heating and cooling cycles are repeated often enough, alternating stresses weaken the material in a way analogous to mechanical fatigue.

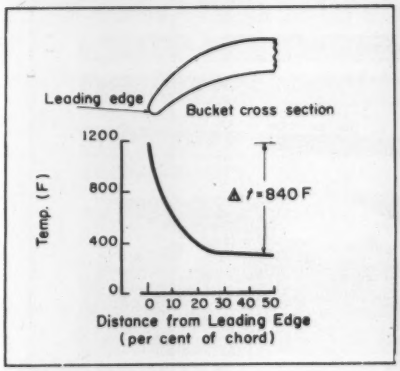
The thin edge of a turbine disc, for example, is near the path of hot gases and heats rapidly, but is restrained from expanding by the relatively cool, massive center. In one case maximum temperature differential across the disc is observed 15 minutes after starting. A blade like the one shown was found to have 840 F temperature differential across ¼ in. of chord during starts. Plastic flow relieves the stress, but repeated starts cause fatigue failures in the form of tiny cracks.

Designers avoid unnecessary restraints in turbines; nozzle blades are free-floating in shrouds; splines are free to slide back and forth. Stress concentrations like notches and pinholes, around which thermal fatigue cracks start, are avoided where possible. Preheating hubs of turbines to 400 F, perhaps with built-in electric heaters may solve the problem in some cases. Use of materials known to be highly heat-conductive should also be considered by the designer. Controlled starting sequence has been found to be of utmost importance, by NASA, in improving turbine bucket life.









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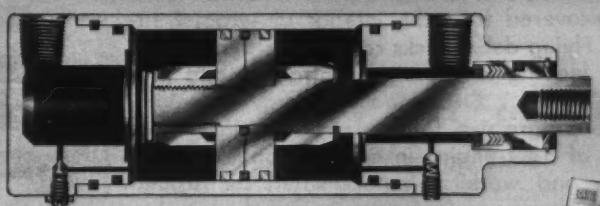

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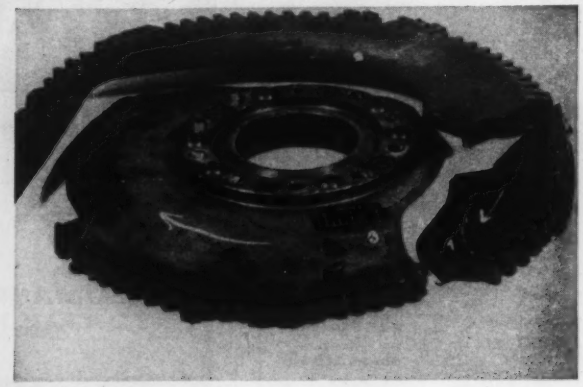
Speed and Temperature

Higher than normal speed, inducing extra centrifugal force, or higher than normal temperature can hasten stress rupture and so are deleterious to components in the turbine section. Overspeed and overtemperature call for better controls. Many present controls are regulated at maximum thrust by a maximum speed governor, on the assumption that if engine speed is constant, gas temperature remains constant too. Inability to account for inlet air distortion needs serious study as a cause of improper control function. Separate speed and temperature sensors may be needed for better protection.



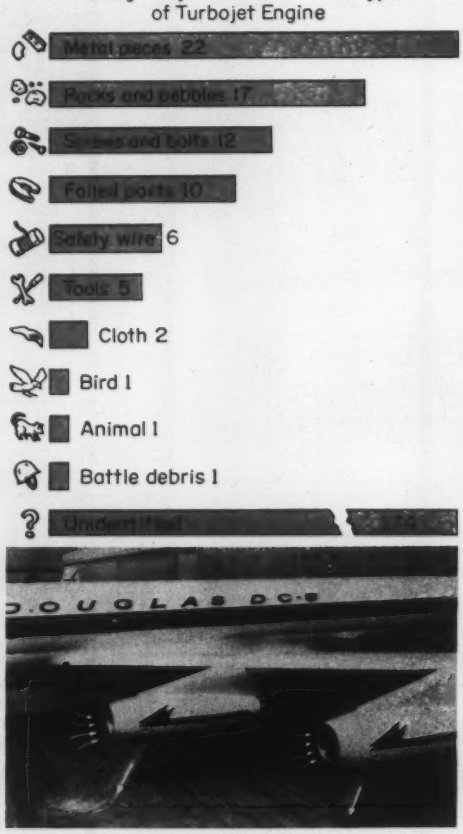
Foreign Objects

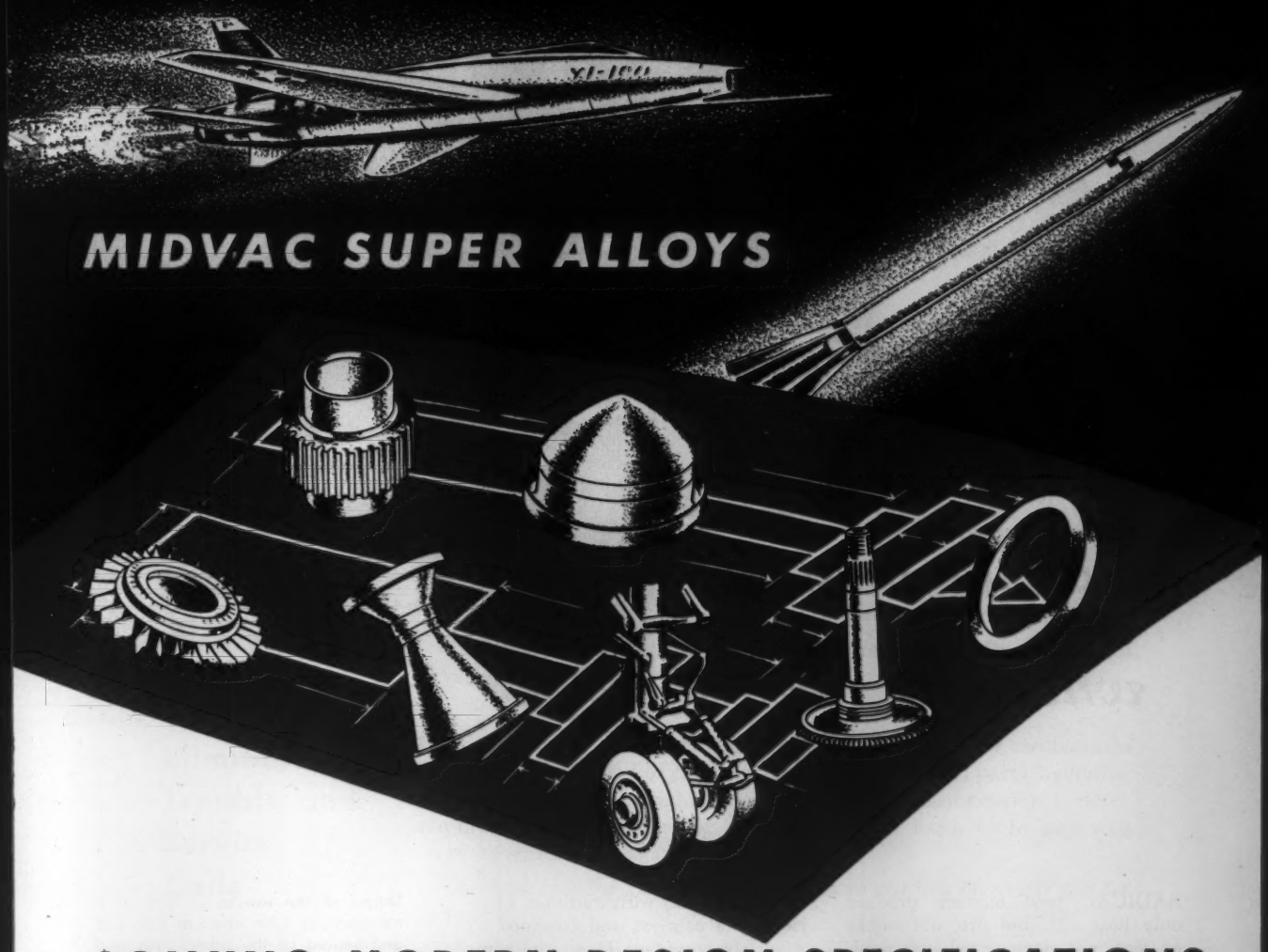
The hurricane of air sweeping into the voracious maw of an air-hungry jet sweeps all sorts of loose debris with it. Vortices generated just ahead of the inlet pick stones, bolts, and wrenches from the ground and hurl them into the compressor. Birds, small animals, broken engine parts, and tools have been recovered from the interior of turbojet engines. Flying debris nicks compressor and turbine blades, leading to stress concentrations and premature failure. Occasionally, it may cause immediate progressive failure, wrecking the whole interior of a jet engine in a few seconds.

Tools and working materials left by ground crew—or even manufacturing personnel—in turbojet inlets are found all too frequently. So are bits of screen, guide vanes, combustor liners, and bolts and rivets. Design of such internal parts needs a generous factor of safety.

Ingestion of foreign materials has stimulated a lot of design research—screens for the inlet, roll-away screens at the airport, removable screens on the aircraft—all have been tried with some success. Special discipline in keeping jet runways and ramps clean and clear of debris and tools has been instituted. A novel device has been developed to deal with ground vortices induced by jet engine intakes. A portion of the jet stream is deflected to the ground in front of the engine to "blow away" the vortex and discourage the sucking up of ground debris.

Foreign Objects Found in One Type of Turbojet Engine





SOLVING MODERN DESIGN SPECIFICATIONS

Parts for Missiles—Rockets—Jet Engines are constantly calling for newer alloys to operate at higher temperatures. Alloys made by the Midvac process of consumable electrode melting are currently answering these needs and new ones are being developed in anticipation of more critical operations.

Midvac Alloys insure increased tensile and impact properties, improved stress rupture strength at elevated temperature, and longer fatigue life.

Standard commercial alloys can also be made with increased cleanliness resulting in higher properties than have been available under conventional means.

Offered in ingots, billets or forgings for the production of missile combustion chambers, tail cone assemblies, jet engine parts, aircraft landing gear components or any other parts requiring properties beyond the capabilities of conventional steels.

MidVac Steels

MIDVALE-HEPPENSTALL CO., NICETOWN, PHILADELPHIA 40, PA.

Subsidiary of HEPPENSTALL COMPANY, Pittsburgh, Pa.

Circle 415 on Page 19

High-temperature hand torch is fed from outside to inside surface. This "inshot" burner uses a minimum area for combustion, which results in higher plasma temperatures—over 3000 F for a unit burning a natural-gas-air mixture.

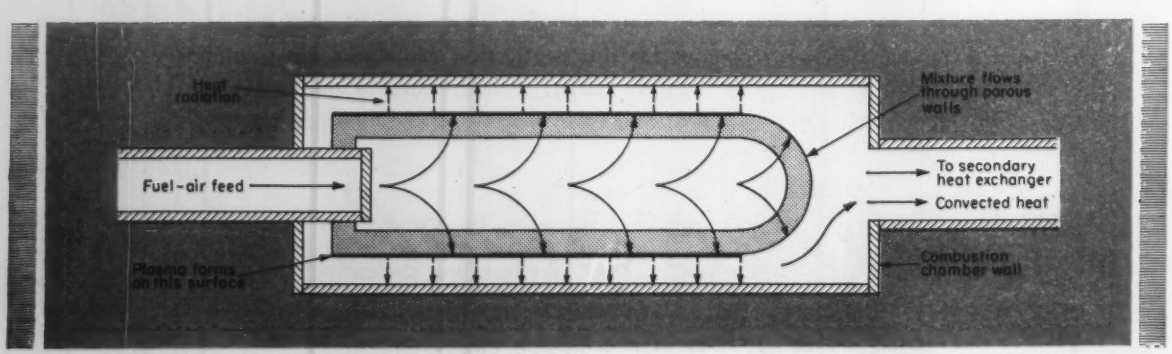
Flameless Burner

puts the heat where it's needed

RADICAL new burners produce only heat . . . not fire, not smoke or soot, not noxious exhaust products . . . just heat. Heat exchangers designed for these burners heat only what needs to be heated . . . not chimneys, not duct-work, not the great outdoors.

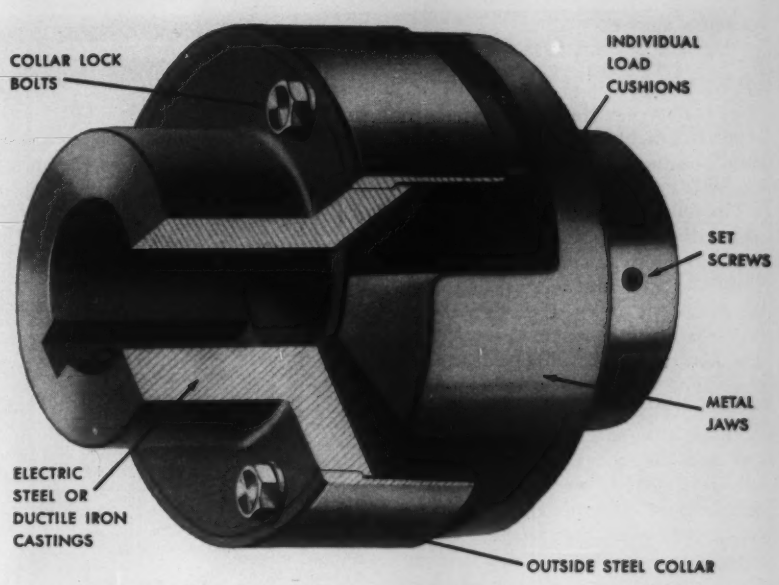
This new level of combustion and heating efficiency is made possible by the design of the burner—it is one that breaks with tradition. Hurried by a catalyst and confined to a surface-boundary layer, the combustion reaction is quite unconventional. A blower drives fuel gas (or fuel-oil vapor) and air through the porous burner-wall, which is made of a catalytic material. No gas-discharge ports are used. All the fuel combusted comes through the wall. The burner—called a Thermocata-

Shape of the reactor is that of a microporous tube open at one end and sealed at the other. Air and fuel injected at the open end are forced through the pores. Combustion reaction takes place on the catalytic surface last encountered by the mixture. Radiant heat is transferred directly to outside walls of the combustion chamber and accounts for more than 75 per cent of the input. Convected heat carried away is recaptured downstream in a secondary heat exchanger.



A Report To Equipment Manufacturers

LOVEJOY TYPES C and H FLEXIBLE COUPLINGS UP TO 4250 hp.



Installed and Aligned In Minutes

Just slide on the shaft, bring the jaws together and insert cushions. A twist of the bolts on the outside collar firmly retains the visible cushions.

Alignment is equally simple. Just use a straight edge. Gauges are not required.

Eliminate Trouble and Service Calls

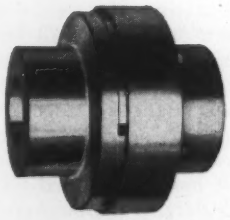
Lovejoy Flexible Couplings contain no intricate parts or mechanisms that require attention or can cause possible trouble. All parts, including cushions, are in plain sight for rapid inspection. Lubrication is never required. Water, oil, dirt or weather will not harm or in any way decrease efficiency.

The best care for Lovejoy Couplings is to *put 'em on shafts and let 'em alone.*

Outlast Equipment Life

Bodies are carefully machined from electric steel or ductile iron castings. The load is entirely transmitted by cushion compression, eliminating metal-to-metal contact and resultant wear on metal parts and jaws.

Even the cushions last longer. First, they are furnished in the material best suited to the service. Second, on non-reversing loads, their life can be doubled simply by reversing or advancing.



Lovejoy Flexible Couplings can be delivered immediately from stock. Heavy-Duty Types C and H run from 18 to 4250 hp. at 1200 rpm. in a wide range of bore sizes. Other sizes and types run from .05 at 100 rpm. to 1020 hp. at 1600 rpm. to provide the most complete selection of couplings available to industry.

Request full information and ask for Catalog C-58. Give details or specifications for prompt quotation.

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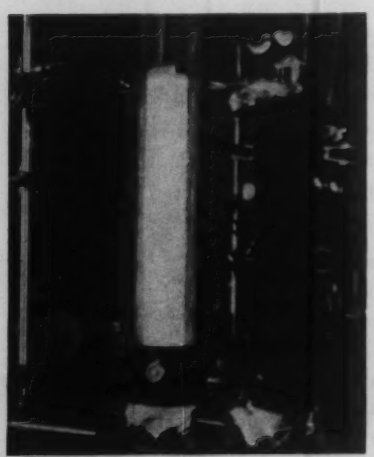
SALES OFFICES THROUGHOUT THE CONTINENT

Circle 416 on Page 19

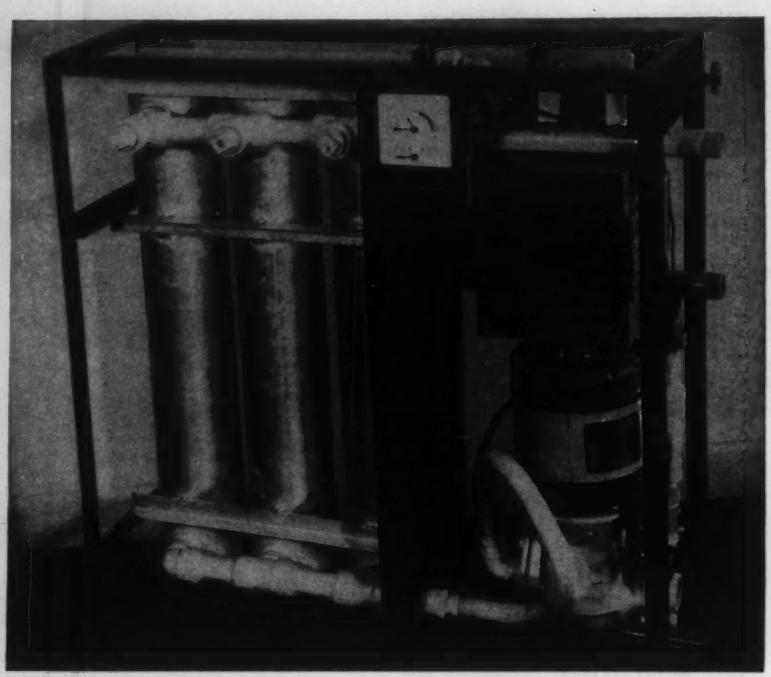
lytic reactor—is the result of years of development work by the American Thermocatalytic Corp., Mineola, N. Y.

Upon ignition, a blue flame momentarily flares up, then settles down to the steady combustion state. This steady state is characterized by a sharply defined plasma layer that sits right down on the reactor. The entire reactor glows incandescent. The surface-plasma temperature depends largely on the choice of fuel and oxidizer (for natural gas and air, the temperature may exceed 2000 F), and the catalyst temperature depends on geometric configuration of the burner. Completeness of combustion depends on the catalyst, i.e., on composition and temperature.

Combustion is extremely stable. Even when amount of air injected is the theoretical minimum for combustion, the carbon monoxide generated is well within limits imposed by modern safety standards. In comparison, conventional burners must be oversupplied with air for safe combustion. When more air is injected in the reactor than is required, combustion is equally good, but back-pressure and plasma temperature decrease. In fact, they fall off so fast that they can be used for sensing to give very accurate control.



Reactor glows incandescent in a glass-wall combustion chamber. Plasma temperatures depend on burner shape and on fuel and oxidizer used. With "outshot" burners and with a natural gas-air mixture, plasma temperatures reach almost 2000 F.



One promising application is a water-circulating central heating system. Three reactors operate as immersion heaters in parallel-connected flash boilers, and water is heated as it circulates. The prototype unit operates at an over-all efficiency of 96.2 per cent.

Fuel-feed rate to the reactor can be varied over a considerable span. Under high-feed rates, the reactor is self-limiting in power output and plasma temperature, and for this reason, does not destroy itself, even when input is extremely high.

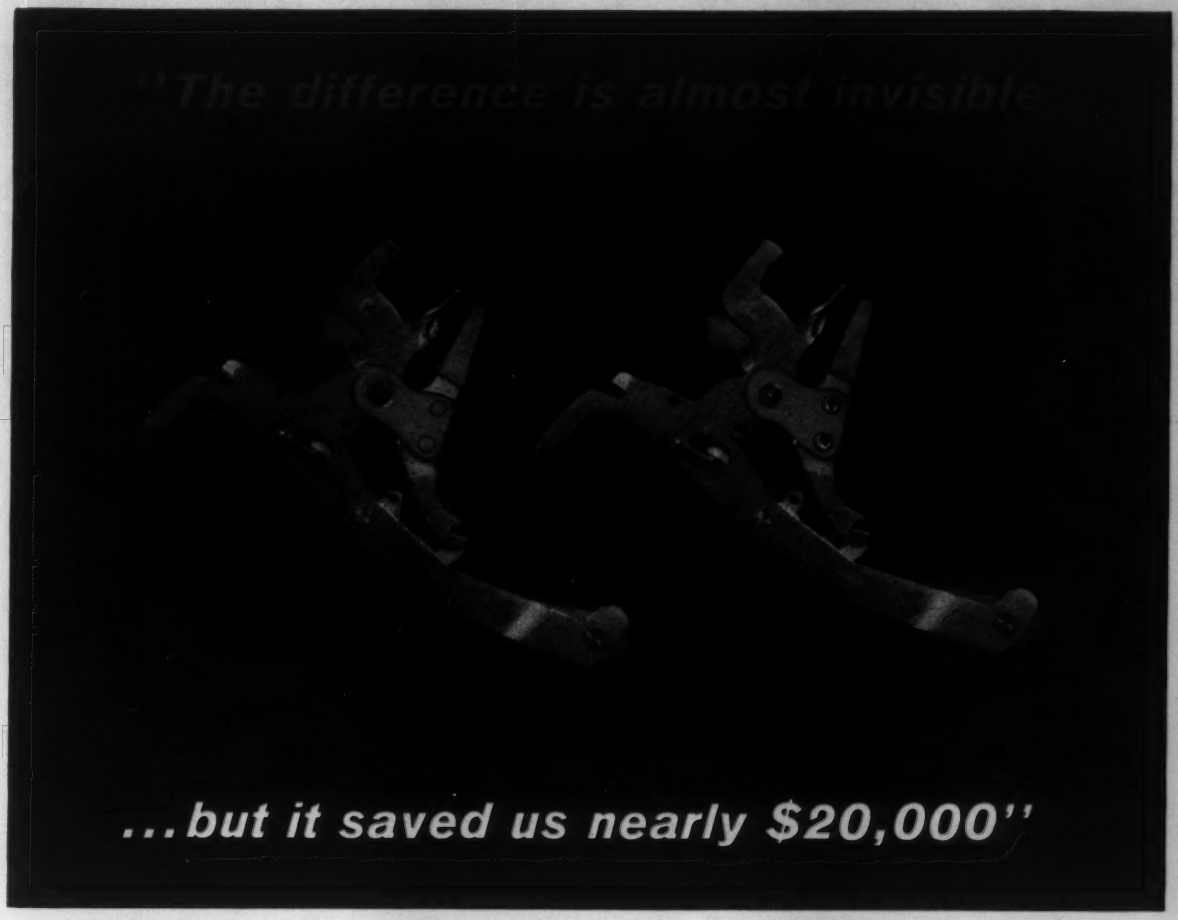
Heating efficiency is exceptionally high. Seventy-five per cent or more of the heat output is transferred directly to the combustion chamber wall by heat radiation. Since the combustion chamber can be immersed in water or mounted in a convection system's air stream, all of this heat can be utilized. In addition, a secondary heat exchanger can be mounted between combustion chamber and exhaust duct to recapture the remainder of the heat. Prototype units for various applications have been constructed with over-all heating efficiencies of better than 95 per cent.

Initially, American Thermocatalytic Corp. developed only a highly active catalyst of unusual properties. Applications of the new catalyst, however, were sharply limited by relatively low "power densities" —heat output per unit reactor surface. Further investigations directed toward improving surface-combustion techniques were so successful that an entirely new combustion phenomenon was obtained!

Large temperature gradients exist in the reactor walls (1700 F in $\frac{1}{8}$ in.), so that an entirely new material resistant to cracking and spalling had to be developed. As it worked out, this material was the key to success.

The microscopically fine structure of the wall prevents flashback under all operating conditions. For this reason, turndown to complete shut-off is possible without backfire. Further, since the reactors are incandescent bodies, not flickering flames, they are not extinguished by drafts. Their low heat inertia permits instantaneous response to regulation—an operating reactor can be picked up in bare hands 5 sec after it has been turned off.

Thermocatalytic combustion systems can be mounted in any position. Since system pressures are higher than ambient, downdrafts and blowback are eliminated. Chimneys are not required, and fail-safe control in case of power failure is entirely practical.



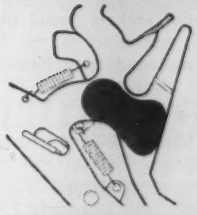
Royal McBee had been using solid rivets and a staking machine to put together an assembly for their Royal electric typewriter. Lots of hand operations, lots of chances for scrap-making fumbles. Still, production costs were satisfactory . . . until suddenly the production rate had to be almost doubled. Costs really jumped.

Their TRS man suggested dropping solid rivets for semi-tubular ones, automatically machine-fed and set, with a special TRS-designed loading fixture to fumble-proof the whole operation. Result: the increased number of perfect assemblies a day . . . with the same operating crew using standard TRS riveters already available at Royal McBee.

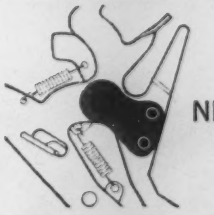
Let the TRS man look over your assemblies. You'll find that he has the viewpoint of a manufacturing engineer, and an unusual knack for making fastening simpler, faster, better.

Of course he will recommend TRS rivets. But he will give you sensible reasons why they are more reliable in essential qualities and uniformity. Superior Quality Control is one significant result of a five-year modernization of this pioneer company. Modernization of people, policies, production and service facilities. *You'll like to do business with the new TRS . . . we'll make sure of it.*

THE CHANGE THE TRS MAN MADE



OLD Two operators assembled 2 solid rivets and 1 shouldered stud into countersunk holes of trip pawl, placed this on a tray, then placed carrier arm over stud. Third operator positioned bearing plate over rivets and stud, lifted the loose assembly from the tray and slid it under a staking machine to stake the 2 rivets.



NEW The countersink is eliminated, in all three locations. On the special TRS sliding fixture, each operator assembles all components over 2 locating pins, with the stud in place. The loaded fixture is then slid into riveting position, and the riveter is actuated by a foot lever to fasten the assembly with 2 semi-tubular rivets.

Don't Buy Riveting Machines until you learn how the TRS **PAR** *process revolutionizes riveting*

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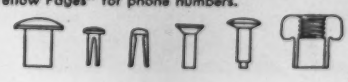


Torsion Bars and Sliding Leaves: New Suspension for '60 Trucks

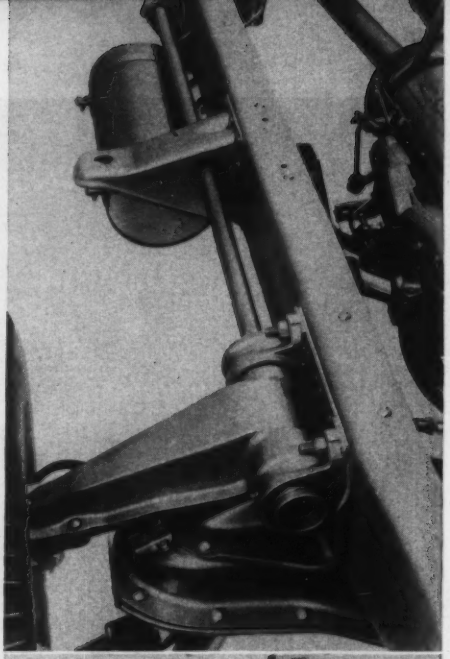
Hard-Riding I-Beam Scrapped by Chevy

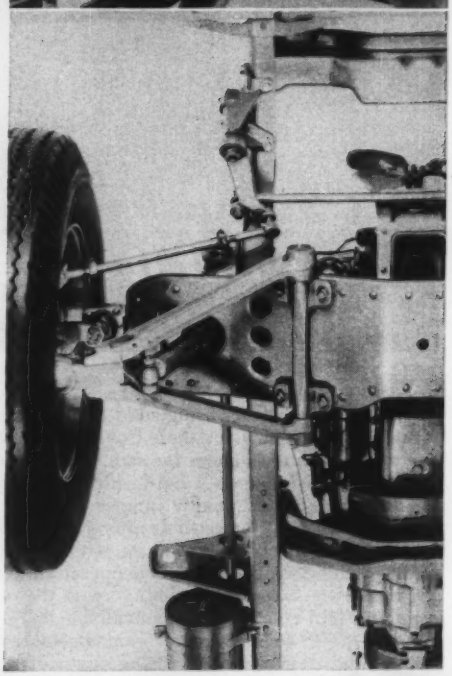
DETROIT—A first for trucks: Independent front suspension with ball joints and torsion-rod springing are pioneered by Chevrolet in its 1960 truck line. Besides greatly improved riding qualities, significant advances in vehicle safety are claimed for the new system:

- Unlike I-beam arrangements in which spring failure may seriously affect steering control, Chevrolet's rigid control arms will maintain front members in position and alignment in event of spring failure. The only change would be a slight vertical drop of one wheel, with little effect on control.

- Independent suspension reduces unsprung weight and provides more positive toe-in and camber control. Because disturbance at one front wheel is isolated from the other, shimmy and "wheel tramp" are substantially reduced.

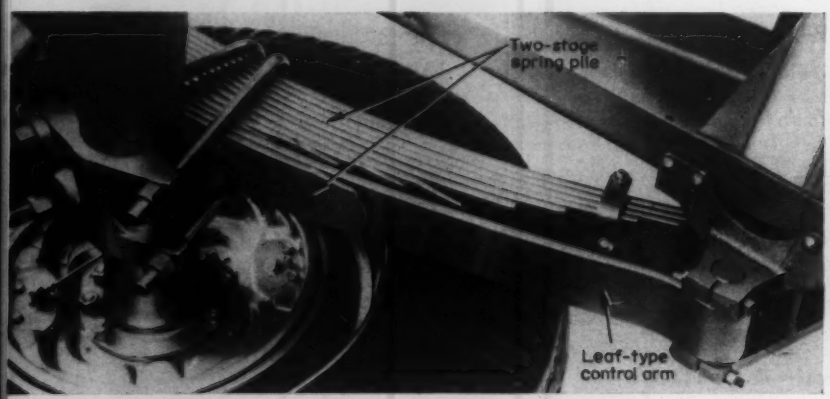
Rear suspensions, also, have been redesigned to provide a softer unloaded ride with a uniform increase in rate as the load increases. New rear spring piles consist of 9 to 11 leaves, depending on truck capacity, with no shackles, bushings, or pins at the ends. Upper leaf rides free against a contoured pad in the fore and aft hangers. At curb weight, only the upper section of the spring pile is in operation. As load increases and deflects the spring, leaves level out. This action, plus the contour of the spring pad, moves the contact point in along the spring pile toward the center where spring rate is highest. It also brings the rest of the pile into play.

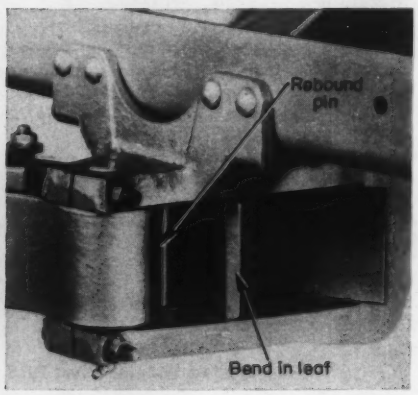




Torsion rods nest in hexagonal sockets inside the upper control arms, above. Rear mountings are anchored to the frame. Lower control arms are durable forgings mounted to a heavy cross-member, right.

Leaf-type control arms, left, absorb driving and braking torque, leaving two-stage spring pile to absorb vertical ride motion only. Canted U-bolts give greater effective spring length. Second leaf in the pile, right, has bent end to engage pin stop and keep assembly in place on rebound or in event of control-arm failure.





This pair combines high offset and high ratio for a compact drive design. The ratio is 2 x 90. The pinion is offset 3½" from gear center.

See how the teeth "wrap around" this high-reduction pinion

This is a high-ratio hypoid gear. In principle, it is not different from more conventional hypoids produced by the Gleason Works. *But . . .*

If you look closely at the pinion, you'll notice that the teeth tend to "wrap around" it. This design is extremely well suited for high reduction, strength and compact design.

The result is a conical (or sometimes cylindrical) pinion which permits *continuous tooth action—even with just one or two teeth!* Compared to corresponding bevel pinions, its diameter is greater for higher strength. An extended shank on cylindrical pinions makes *very rigid* straddle mountings practical.

You can design a *compact* unit, because high offset is possible! For high-offset *or* high-ratio pairs, the "wrap around" tooth design provides an extra measure of the smooth, quiet tooth action of hypoid gears.

High-ratio hypoids can be cut on the same Gleason equipment that is used on more familiar spiral bevel gears and hypoids. You can also use the same testers, quenching presses and other auxiliary Gleason equipment you're using now. Grinders are available for applications requiring precision finish.

High-ratio hypoids can be produced by the Gleason Works for ratios of 1:10 or 1:40 or even higher. They are finding a growing number of applications in such diverse fields as farm machinery, instrumentation and office equipment.

You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

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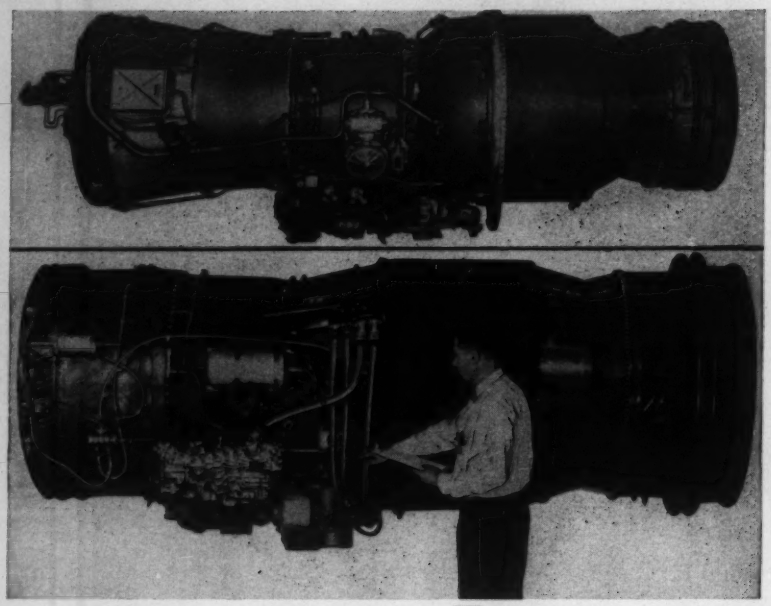
Navy Speculates on Giant Turbojet

Multimillion-Dollar Project Seeks Mach-3 Engine for Navy

PALM BEACH, FLA. — Development of the J58, Pratt and Whitney's 30,000 lb-thrust, Mach-3 turbojet engine will be continued under an $11.2 million Navy contract. The single-spool engine—1½ times as big around as a J57, and about the length of a J75—marks a deviation from P&WA's highly successful twin-spool formula.

So far, the engine has not been fitted to a Mach-3 airframe. Largest Navy carriers are now operating at full flight-deck capacity with Mach 2 aircraft. To quote Vice Admiral J. T. Hayward, "We are now approaching the limits in aircraft that can operate from carriers"

Experts refuse to comment on the possibility of larger carriers in the offing, and are equally mum about the future of projected Navy land-based operations.



Single-spool J58 shows a stubby, power-packed profile in contrast to the more slender silhouette of aviation's racehorse of the 50's, the twin-spool J57 (above).

Metals Matters

Aluminum core improves . . .
operation of stranded tungsten wire used for vacuum metallizing. Coils made from this wire "wet" more quickly and last longer, as well as giving improved service. When the wire is heated, the aluminum core vaporizes, leaving an open-mesh wire which gives up to 80 per cent more production than the close-woven wire previously used. General Electric points out that even "wetting" helps lengthen coil life, since it reduces hot spots caused by balling of aluminum.

Titanium for boilers . . .
heat exchangers, coils, and tanks will be covered by an ASME Boiler Code. This action permits routine insurance coverage of equipment conforming to specifications without costly special investigations. The code gives specifications for internal pressure applications using Ti-45A, Ti-55A, and Ti-65A grades, as well as cylindrical and spherical vessels using T-65A in external pressure applications. Welding requirements, inspection and stress relief procedures, and allowable stress values at titanium temperatures up to 650 F are also spelled out in the Code.

Long-life zinc-coated bolts . . .
are possible with a newly developed zinc finish. A characteristic "blue brightness" makes the fittings well suited to applications where high finish is desirable. Secret of the process is an additional dipping process after the customary zinc finish. Republic Steel Corp. says the fasteners last up to twice as long as fasteners with conventional zinc electroplate.

Temporary aluminum coat . . .
prevents oxidation of extrusions during transit. Developed by Harvey Aluminum, Torrance, Calif., Anocote coating does not affect the finish of the metal in any way. Fabricators who anodize or etch their extrusions report the surface of Anocoted aluminum is exceptionally smooth, uniform, and free of surface defects. At present, the protection is supplied by Harvey only on extrusions of alloy 6063.

Cesium, rhenium, and rubidium . . .
will get the spotlight treatment from the U. S. Bureau of Mines during 1960. The metals are needed for expanding use in high-temperature electronic, nuclear-energy thermoelectric, and astronautical fields.

Common low-alloy steels . . .
are getting the consumable electrode vacuum melting treatment once reserved for exotic refractory metals. Reason is that for critical applications in the aircraft and missile fields, steels made by the consumable electrode process are more dependable. Allegheny Ludlum Steel Corp. says the metals will be used for solid propellant motor cases for rockets; valve springs, and piston pins for reciprocating engines; and jet-engine gears, bearings, and shafts.

Co-ordinating center . . .
will store information about exotic and refractory metals. Air Materiel Command installations and their contractors will forward data to Defense Metals Information Center, Battelle Memorial Institute, Columbus, Ohio, says AMC Commander, General S. E. Anderson. The Center's scope has been enlarged by the Department of Defense to include beryllium, refractory metals, high-strength alloys for high temperature service, coatings for corrosion and oxidation resistance, and thermal protection systems. It was formerly called the Titanium Metallurgical Laboratory.

GOODYEAR

Pulling together pays off more than ever before when you use the new "Plus-Rated" V-Belts with the Green Seal by Goodyear. See for yourself—

Year after year–at plant after

Goodyear V-Belts with

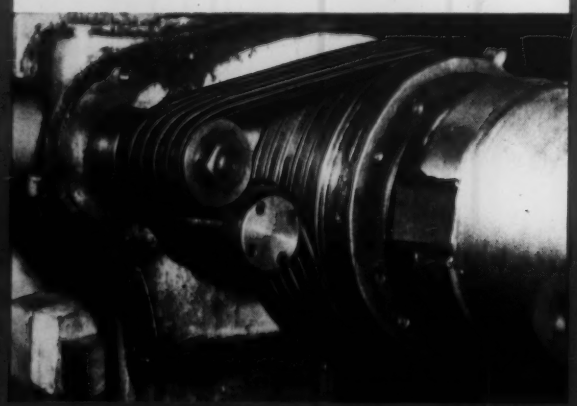
the toughest jobs–at the lowest cost

–IN AN ILLINOIS GARAGE EQUIPMENT PLANT

Operation: Finishing surfaces of cylinders used on automobile lifts

Drive: Oily main drive of heavy-duty cylindrical grinder

Service: Set of 5 matched oil-resistant V-Belts with the Green Seal pulled together to give user 6 times the service of previous belts

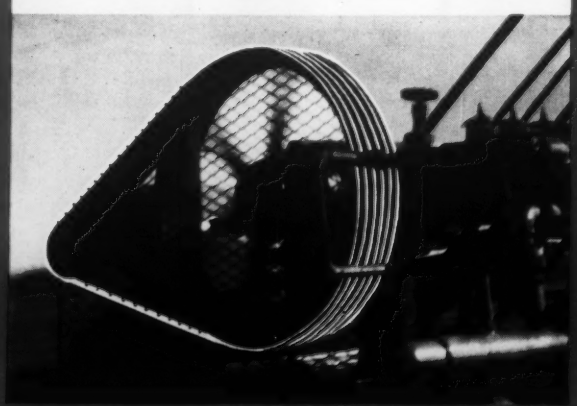


–ON TEXAS WATERFLOODING PUMPS

Operation: Pressure-pumping salt water into "tired" oil wells to reactivate them

Drive: 15 h.p. pump drive that feeds salt water into wells under 600-900 psi pressure

Service: Five-belt set of V-Belts with the Green Seal pulled together, eliminating slippage problem caused by previous belts and averaging 2 years' service where others had failed in 6 months



–and now they're "Plus-Rated" for greater

plant–on drive after drive–

the Green Seal handle

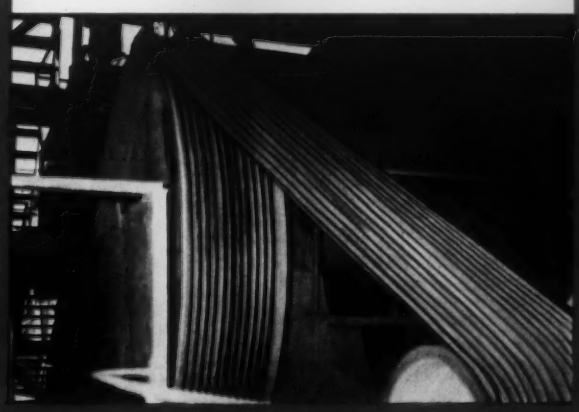
–over the longest trouble-free life–

–AT AN OREGON LUMBER MILL

Operation: Debarking giant logs
Drive: 25 h.p. 900-1800 r.p.m., 2-speed main drive on barker
Service: Matched V-Belts with the Green Seal–five to the set–pulled together and outlasted previous belts 14 to 1–eliminating down time–saving $40 a month to boot

–ON A PENNSYLVANIA ROCK CRUSHER

Operation: Crushing dolomitic limestone
Drive: Main drive on bulldog-type rock crusher
Service: Set of 14 matched V-Belts with Green Seal construction pulled together to crush 600,000 tons of limestone a year for 14 straight years–was still going strong at last report



horsepower-transmission per dollar!

HERE'S THE STORY .....

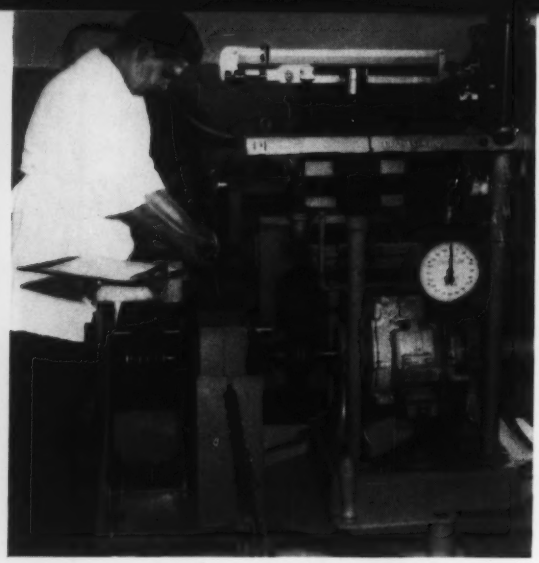
New

"Plus-Rated" V-Belts

with the

Green Seal

give you all these "pluses"



- Bonus horsepower ratings at no extra cost
- Maximum horsepower hours per dollar of any belt you can buy
- Matched V-Belt sets that *stay* matched in storage—on the drive
- Unequaled stretch-resistance – thanks to high-modulus construction with load-carriers of airplane-type steel cable or 3-T cord
- Smooth-running uninterrupted performance with specially compounded non-dusting rubber covers that never stick in the grooves
- Maximum resistance to shock-loads—guaranteed by breaking-point tests that exceed the strain of severest service

—Add up all these plus features and you'll see why the new "Plus-Rated" V-Belts with the Green Seal are your best belt buy for longer-than-ever, more-trouble-free service at lower-than-ever cost. For details, contact your Goodyear Distributor—or clip, fill in, and mail the coupon below.

Green Seal—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

"PLUS-RATED" V-BELTS WITH THE GREEN SEAL BY

GOODYEAR

THE GREATEST NAME IN RUBBER

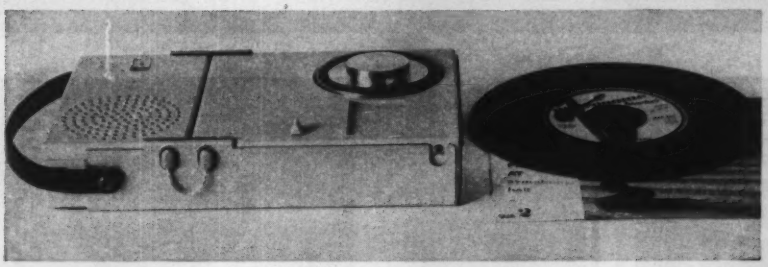
S-51168-K

THE GOODYEAR TIRE & RUBBER COMPANY, Industrial Products Division, Dept. 794, Akron 16, Ohio
Please send me more information on the great new "PLUS-RATED" V-Belts with the Green Seal.

Name .....

Company .....

Street Address ..... City ..... Zone ..... State .....



Portable Music System

Miniature record-player connects to transistorized radio to form a portable music system having less area than this page. The 9½ in. by 6 in. by 2 in. combination, designed and manufactured by Max Braunn, Frankfurt/Main, Germany, plays up to 1000 records from one set of four 1.5-v dry-cell batteries. The crystal pickup, normally retracted in a plastic housing for protection, extends to contact the bottom side of a record. The radio can be disconnected from the combination for separate use. The unit will receive short, medium, and long radio wavelengths, and will play 45-rpm records.

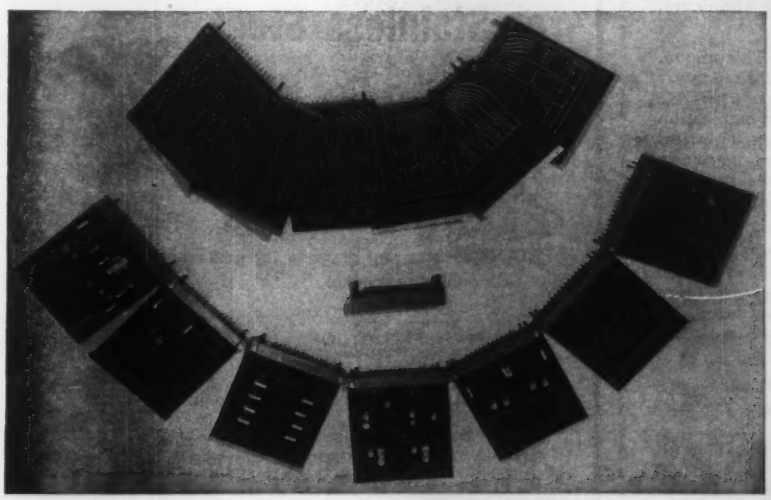
NBS Simplifies Data Processing

Packaged Computer Circuits Cut Research Time and Costs

WASHINGTON—Much of the drudgery in data recording and preliminary processing is being eliminated at National Bureau of Standards through the use of versatile electronic building blocks. The small, transistorized packages, developed by Bureau scientists, can be connected together systematically to accept raw data from experimental equipment, and transpose the data into a form suitable for direct input to high-speed computers. Output from the system can also be used to drive display equipment for the step-by-step observation of a particular experiment.

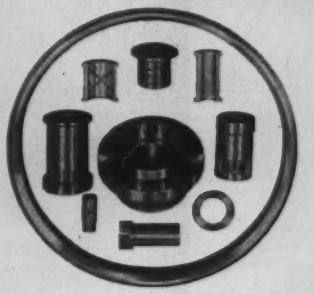
The new units are used to ad-

(*Please turn to Page* 44)



Special-purpose computer packages, developed by National Bureau of Standards, perform logical operations required for electronic data processing and recording. In the upper row, from left to right: OR-inverter; indicator; flip-flop; power gate driver; gating circuitry; analog switch; and "one-shot" pulse generator. Lower row shows reverse sides of a number of packages. The units can be connected together into a system that takes raw data from experimental equipment and processes it into a form suitable for direct computer input.

A LITTLE STUBBORNNESS GOES INTO OUR SLEEVE BEARINGS



Producing bronze sleeve bearings requires more than special tools and techniques. It demands proven design experience such as we have acquired through 25 years of bronze bearing production. That's why we seem so insistent sometimes in our efforts to help with your bearing design. We have learned the hard way and are more than willing to share our experience with you. When we are convinced that a change will improve the bearing, cut production costs or ease assembly operations, you'll find our objections firm though constructive.

So if you would like experienced help with a particular bearing design problem—even to the recommendation of the proper alloy — be sure to take advantage of our specialized knowledge. We offer a full range of sizes in both cast and sintered bronze bearings including grooved and graphited items. In fact, it's the largest variety of bronze bearings available anywhere.

Would you like some useful information for your files? See the coupon below.

A Founding Member—
Cast Bronze Bearing Institute

RENEWAL SERVICE INC.
1705 Lehigh Ave., Phila. 32, Pa.

Send me "Chemical and Physical Specifications of the Bronze Alloys" which includes MIL., SAE, Navy, Aero., ASTM, and Fed. Spec. Comparatives.

Name_____

Company_____

Address_____

Renewal Service INC.

Circle 420 on Page 19

PEM FIRST NAME IN

THE

original

SELF-CLINCHING FASTENER

Fifteen years ago Penn Engineering and Manufacturing Company introduced the self-clinching fastener, providing load-bearing threads in a wide range of—steel, aluminum, brass and copper sheets, "too thin to thread."

THE ANSWER TO PRODUCTION FASTENING—This unique, exclusive design was immediately recognized as the answer to production fastening by leading manufacturers of aircraft and missiles, automotive, electronic and communication equipment, business machines, farm machinery, electrical appliances, transportation equipment, vending machines, home appliances, etc. Stimulated the cost-conscious sheet metal assembly techniques utilized, today, by many of these manufacturers.

INSTALLED BY A SQUEEZE with the greatest of ease (without special tools) Users tell us that—because the shank of PEM nuts acts as their own pilot . . . because, being round, they require no indexing . . . because they require no special tools . . . because several may be pressed into place in a single operation . . .

THEY SAVE THEIR COST MANY TIMES OVER . . . in time, labor and special equipment. PEM nuts are one of the most profitable items in the assembly line.

Today, PEM Self-Clinching Nuts are made in six types for sheet thicknesses from .030" and up—in steel (with various rust resistant finishes), stainless steel, monel and aluminum. Sizes range from #2 to ¾". Also made as Blind Fasteners for pressure seal applications.

For complete information, write on your letterhead for Bulletin No. CL359 and sample.

Circle 421 on Page 19

specify

PEM WELD FASTENERS of Steel or Stainless Steel

PEM Weld Fasteners are designed for production . . . Faster Assembly . . . Lower Equipment and Labor Costs . . . and corrosion resistance, too, when required.

SHANK locates and protects threads against weld splatter . . . eliminates retapping.

ENGINEERED PROJECTIONS prevent burnouts in thin sheets.

SIMPLE ELECTRODES . . . no pilots required.

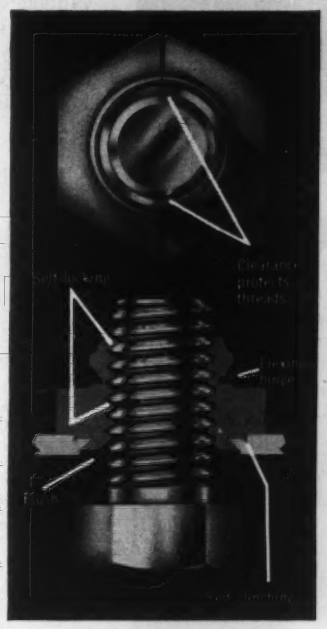
ROUND COMPACT SHAPE . . . no indexing in assembly . . . fit on narrow flanges.

Write on your letterhead for Bulletin WN-1158 and sample for trial.

Circle 422 on Page 19

PENN ENGINEERING & MANUFACTURING
New York (Bells Harbor, LI)—Neptune 4-7103 Chicago (Forest Park, Ill.)—Forest 8-4971 Detroit—University 3-3189
Cincinnati—Humboldt 1-4261 Indianapolis—Clifford 1-4020 Milwaukee—Hayward 8-6118

CAPTIVE FASTENERS



ALL-METAL SELF-LOCKING SELF-CLINCHING PEM NUTS

are tops in performance

Combine two essential functions in one lightweight, low-cost unit.

The self-clinching feature is the same tried and proven original PEM design, recognized by industry as the answer to production fastening. It is installed by a squeeze into sheet metal, too thin to thread, by standard pneumatic, hydraulic or mechanical presses.

The all-metal, self-locking feature offers distinct lock-nut design improvements required for top performance under temperature, vibration and stress requirements of such high-reliability services as missile, rocket, aircraft and electronic components.

Exclusive Design • Outstanding Advantages: The All-Metal, Self-Locking features of the new PEM Nut speak for themselves:

ONE SLOT design: two rugged semi-circular jaws with inherent flexing action—far stronger than several less-supported segments.

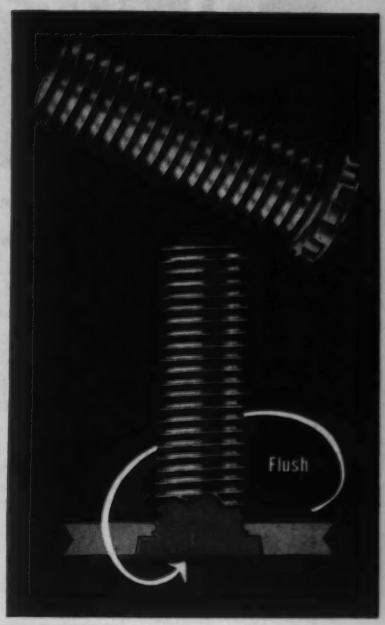
FLEXING HINGE: a machined slot at the base of each semi-circular jaw retains inherent flexing action, permanently. Guarantees against relaxation and loosening in severe service. Permits reuse, repeatedly, without diminishing self-locking efficiency.

PROTECTS THREADS: fewer segments—plus relief of cutting edges of single slot design, to provide clearance, insures that *no* cutting edges come in contact with the screw.

Made in #303 stainless steel (temperatures to 800° F); steel (temperatures to 500° F); high strength aluminum alloy (temperatures to 250° F); in sizes from #4-40 to #10-32 for use in aluminum, brass, copper, and cold-rolled steel sheets of thicknesses from .040 up and stainless steel sheets from .050 up.

Write on your letterhead for literature and sample for test.

Circle 423 on Page 19



now PEM SELF-CLINCHING CAPTIVE STUDS

"installed by a squeeze with the greatest of ease"

Answering Industry's demand for a captive stud employing the same unique design as the line of PEM captive Self-Clinching Nuts—which ushered in production fastening in sheet metal assembly—Penn Engineering and Manufacturing Corp. has produced the PEM flush-head self-clinching stud.

Saving time, labor, weight on tough assembly jobs, these studs make a surprisingly simple operation out of what formerly was accomplished by various slow and costly makeshift assembly methods, such as welding.

You simply place the studs—one or several at a time—into drilled or punched holes in the panel and squeeze them into place with any standard pneumatic or oil-hydraulic squeezer or mechanical press.

The squeezing action embeds the head projections into the sheet—the displaced metal flowing smoothly and evenly around the back-tapered shank and annular groove to securely lock the stud into the panel with high torque and pushout resistance.

Try them. Write on your letterhead for literature and sample. Sizes from #4-40 to 5/16-18. Carbon steel or #305 stainless steel, for use in various aluminum alloys, brass, copper, cold rolled steel and similar sheets in thicknesses from .040 up.

Circle 424 on Page 19

PEM

CORPORATION, DOYLESTOWN, PENNSYLVANIA

Kansas City, Mo.—Grand 1-6314 Phoenix—Whitney 5-0680 Los Angeles—Bradshaw 5-8097
Birmingham—Blake 5-5761 Dallas—Fleetwood 7-5713 Miami—Tuxedo 8-4570

Moccasin BRONZE SLEEVE BEARINGS

Let Oil Carry the Load

Take advantage of the load carrying capacity of the oil film in a bronze bearing. The oil film can carry loads up to 20,000 psi in a correctly designed bearing. Correctly designed bronze bearings offer outstanding advantages. See the example below where the load carrying capacity of a bearing was doubled by correcting the oil groove at no additional cost.

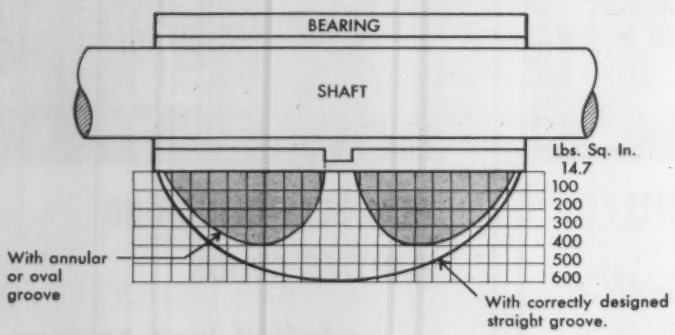
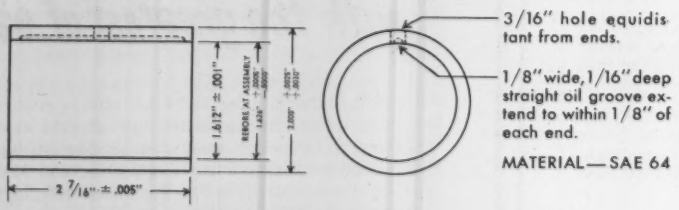


Diagram of oil-film pressure showing load carrying capacity of oil-film.



Correctly designed bearing which more than doubled load carrying capacity by correct oil grooving alone.

Moccasin engineers will be glad to make suggestions and recommendations on new designs. Moccasin has helped many companies redesign existing bearings to increase life, lower friction or to reduce costs. Moccasin has been serving original equipment manufacturers for over 50 years. We invite your questions.

MOCCASIN BUSHING CO.

"Quality Bronze Since 1908"

MEMBER OF CAST BRONZE BEARING INSTITUTE

2000 Chestnut Street ● Phone AM 7-9554

CHATTANOOGA 8, TENNESSEE

(*Continued from Page 41*)

vantage where 1. Data are produced in large volumes. 2. Data taking is extremely fast, extremely slow, or extremely precise. 3. Need exists to minimize human error and tedium. 4. Computation is extensive.

According to the Bureau, automating routine data handling in scientific experiments permits substantial savings in time and labor, as well as increased quantity and reliability of work output both in basic exploratory research programs and in routine calibration and testing.

So far, seven specialized electronic circuits have been developed. Each circuit is constructed on a 4 by 5-in. plug-in printed board and uses electronic components that are common stock items.

Small Foil Capacitor Fires Million-Amp Spark

Less than 20 in. long, a metallic paper capacitor mounted in a metal cylinder stores enough potential energy to be useful in nuclear-fusion experiments. It can discharge a 1-million-amp arc within one millionth of a second, generating high temperatures necessary for fusion research. Designed by Robert Bosch, GmbH, Stuttgart, Germany, the capacitor has a self-inductance of only 0.3 mu h, believed to be unprecedented for a unit of its size. Discharge tube on the upper end of the capacitor simulates a fusion-reaction chamber.

Densitometer Determines The Value of Cleanliness

STAMFORD, CONN.—New test equipment answers the question "how clean is clean?" by assigning a thousand different values to cleanliness. Intended for all contaminants except soils bonded to the surface, the device can evaluate cleanliness and cleanability of a surface and cleaning power of detergents. Developed by Jones & Laughlin Steel Corp., Pittsburgh, it is licensed for manufacture to Branson Ultrasonic Corp., Stamford, Conn.

It works like this. First, soil is removed from the test surface with transparent, pressure-sensitive tape. Next, the tape and dirt combination is fixed to a microscope slide. Then, the slide is inserted into the instrument where density of the tape-dirt glass combination is determined by optical methods.

This density value is indicated by a scale reading between 0 (very dirty) and 1000 (hygienic). The wide range of readings is significant because of a ten-turn potentiometer used in a balancing circuit. The method is reportedly more exact than former methods, because the earlier methods did not evaluate the finely divided soils adhering to a surface.

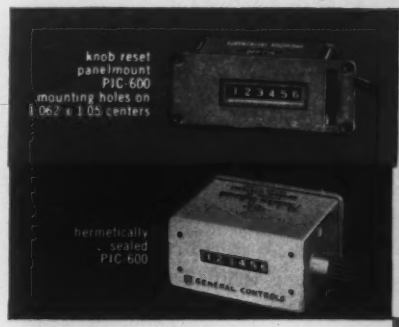
The instrument can also be used to compare various cleaning techniques and equipment and to evaluate effectiveness of cleaning agents.

Soil sample removed from the test surface by a transparent tape is fixed, tape and all, to a microscope slide. Optically determined density of the composite is indicated on the calibrated scale of the densitometer.

123 COUNTERS FOR ELECTRONICS AND INSTRUMENTATION

PIC-600 quiet electric counter offers great advantage for low level DC circuits - draws only .14 amperes from 30-volt transistor circuit.

QUIET OPERATION Efficient magnetic circuit and balanced mechanical action result in smoother operation with reduced noise



RECTIFIED FOR AC Eliminates AC hum—gives DC operating reliability from 25/40/50/60 cycles.

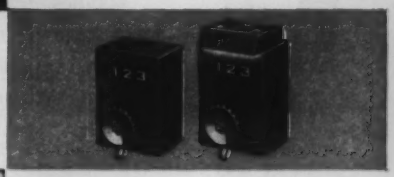
50 MILLION COUNT LIFE On life tests at 1000 cpm pass 100 million counts.

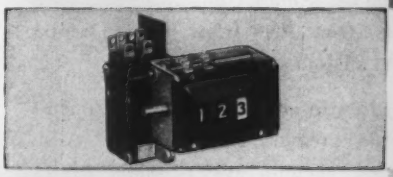
1000 COUNTS PER MINUTE Much higher speeds with suitable actuating impulses.

BALANCED ARMATURE Smooth, quiet operation and low friction in any position.

Also available to count dozens, coins, pairs, quads, etc.

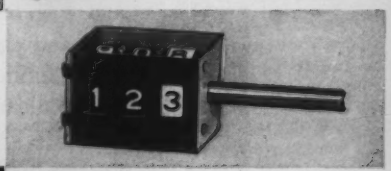
TURNS COUNTER FOR POTENTIOMETER
Gives hundredth turn readings visible when fingers are on adjusting knob. Registers to 999 and repeats. Friction lock secures setting. Available with dial light and for remote operation. →





INDEXING METER WITH SWITCH
Developed for use with wire and tape recorders. Switches are actuated automatically at fixed "index numbers" for which the unit is built. Many variations available for a wide range of application. ←

LOW BACK-LASH COUNTER ASSEMBLY
Rugged, add-subtract revolution counter assemblies widely used as indexing registers for potentiometers, variable capacitors and other digital readout requirements. Wide choice of optional features. →



7-DIGIT REVOLUTION COUNTER
Non-reset. Adds or subtracts 10 counts per shaft revolution. Top-coming or top-going shaft rotation. Totally enclosed in die cast housing. Available sealed; also with adaptor for flexible shaft drive. ←

Manufacturers of Counters. Switches. Relays. Actuators and Automatic Valves

AUTOMATION CONTROLS DIVISION

GENERAL CONTROLS CO.

8062F McCormick Boulevard, Skokie, Illinois

Representatives and Distributors in Principal Cities of United States and Canada

Circle 426 on Page 19

Chemiseal®
NYLON PRESSURE TUBING

Offers you more design "leeway"

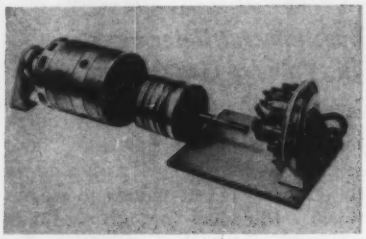
You can flex it, twist it, bend it. In fact, you can shape CHEMISEAL Nylon Pressure Tubing into practically any contour. Think what this means to you in design freedom and versatility!

A Superior Design Material. CHEMISEAL Nylon Pressure Tubing is unaffected by oils, alkalies, hydraulic fluids, and many solvents that tend to corrode metal. It resists vibrational fatigue, abrasion, impact . . . withstands temperatures from −60° F. to +180° F. (can be heat stabilized for 300° F.) . . . available in 1000 and 2500 psi. grades, conforming to J.I.C. specifications. Diameters from ⅛" O.D. up, depending on customer needs.

Typical applications are hydraulic and pneumatic systems, pressure lubrication lines, oil and fuel lines, vacuum system connections, food and chemical processing lines. Find out how CHEMISEAL Nylon Pressure Tubing can help you; contact one of The Garlock Packing Company's 26 sales offices and warehouses in the U.S. and Canada, or write for Bulletin NPT.

THE GARLOCK PACKING COMPANY,
Palmyra, New York

United States Gasket Plastics Division of GARLOCK



Small Motor Delivers 27 hp

Brush-shifting dc motor, 8-in. diam by 10-in. long, is capable of 27-hp output. The unique design calls for two commutators and double armatures; both armature and field rotate. Rated at 90 v dc, 300 amp, the lightweight (55-lb) motor operates at 5900 rpm with an efficiency of 75 per cent. It was initially developed by Bekey Div., Genisco Inc., Los Angeles, for use in an underwater propulsion device.

Color Correction Is Complete With New Optical Lens Formula

Three-Glass Lenses Can Now Be Chosen

ROCHESTER, N. Y.—Three-element lenses can be fully corrected for light from 365 to 1010 millimicrons, i.e., from the ultraviolet to the infrared. This is possible because of an improved optical formula devised by Dr. Max Herzberger, Eastman Kodak Co.

Current lenses are normally corrected for two colors only. They represent a compromise; correction for two colors may cause chromatic aberration for the other colors in the spectrum. In a camera this aberration results in images of different colors being slightly displaced on the film. Previously, "short flints" were about the only special three-lens glasses able to be three-color corrected. Now, a great number of glasses permit design of a three-lens unit in which all colors are in perfect register.

The new formula requires four parameters be known for each glass before refractive indices can be calculated. But a graphical method for determining correct glass combinations requires knowledge of only two of the parameters. The two parameters determine a point on a linear graph, i.e., they are entered as ordinate and abscissa values.

Circle 427 on Page 19

Then, any three glasses represented by points lying on a common straight line can be joined to form a color-corrected three-element lens system.

Kodak scientists have already designed telescope objectives with the new lenses. They are now working on camera lenses and infrared optical systems.

Military Men of the Future Will Be More Like Engineers

Military, Naval Academies Broaden Science Studies

WASHINGTON — Space-age curriculums to develop space-age officers have broken away from military tradition. Science and engineering courses imposed on West Point and Annapolis cadets are on the increase, at the expense of tactical instruction, military hygiene, and other vocational courses.

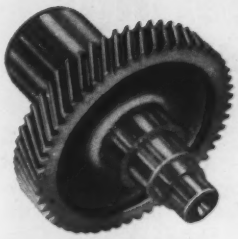
Revisions in the West Point curriculum resulted from more than two years of soul-searching, fact-finding, and evaluation by the Academy staff. More nuclear physics, electronics, chemistry, and more emphasis on logic and research techniques will be characteristics of courses starting this term.

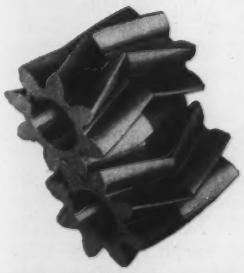
Revisions in the Annapolis curriculum, also resulting from a soul-searching process, include substitution of thermodynamics and fluid mechanics for the study of Naval boilers and more general emphasis on basic science and mathematics. For example, the Ordnance and Gunnery Dept., renamed the Weapons Dept., has shifted emphasis from the uses of existing weapons to the mechanical and analytical basis of weapons; one new course to be taught will be Principles of Trajectory Mechanics.

In another revision of the Annapolis program, elective courses are now offered to students with high grade averages. The electives will be added to the normal study loads instead of being substituted for other courses. Electives offered include Finite Mathematics Theory, Matrix Theory, Atomic and Nuclear Physics, Computer Theory, and others.

Psst, Gentlemen – there's no argument!

Let SIER-BATH show how you can get PRECISION GEARS that actually cost less!





Sier-Bath designed and manufactured precision gears provide:

—VIRTUALLY BREAKDOWN-FREE OPERATION

—VASTLY INCREASED MACHINE PRODUCTION

—NOISE-FREE, VIBRATIONLESS MACHINE OPERATION

... all of which increase sales for your machines when Sier-Bath gears are used. These increased sales, savings and ASSURED SATISFACTION are no further from attainment than a 'phone call or postcard to Sier-Bath.

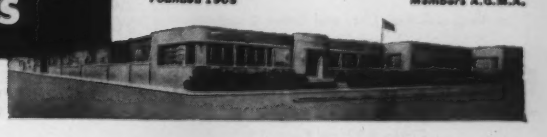
FREE DIAGNOSIS. Without cost or obligation, Sier-Bath gear specialists will study your gear prints and applications—engineer your drawings and gears—determine the one best gear design for each application to operate most economically, efficiently and advantageously in your machines.

If your requirements are for 12 or more of a kind (depending on size), send us prints for quotation and ask a Sier-Bath specialist to come and give you a complete gear survey.

Sier-Bath PRECISION GEARS

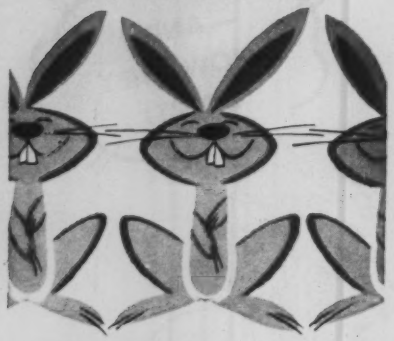
All kinds of gears—all materials
Made—cut—shaved—ground tooth
42" maximum diameter
12 or more of a kind, depending on size.

Sier-Bath GEAR & PUMP CO., Inc.
9237 HUDSON BOULEVARD NORTH BERGEN, N. J.
Founded 1905 Members A.G.M.A.

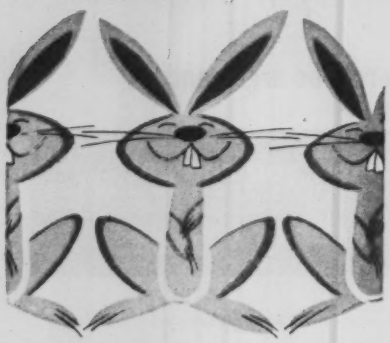


Also manufacturers of Rotary Pumps and Flexible Gear Couplings

The difference in



MICROTOMIC
DRAFTING LEADS



is that they're all alike!

The point is—a Microtomic 2H is a 2H is a 2H . . . **regardless of where or when it was purchased.**

The consistent uniformity of degree in MICROTOMIC Leads is one direct result of EBERHARD FABER's pencil quality control which also results in unusual point strength . . . sharper, blacker lines. They're *sure-fired* — at 10,000 degrees F. — for smooth drafting! In 17 *consistently graded* degrees . . . one dozen to flip top box with handy point sharpener. Use with MICROTOMIC Lead Holder. You'll agree it has a grip that's great!

Tm. Reg. U.S. Pat. Off. and Other Countries

110th Anniversary, 1849—1959

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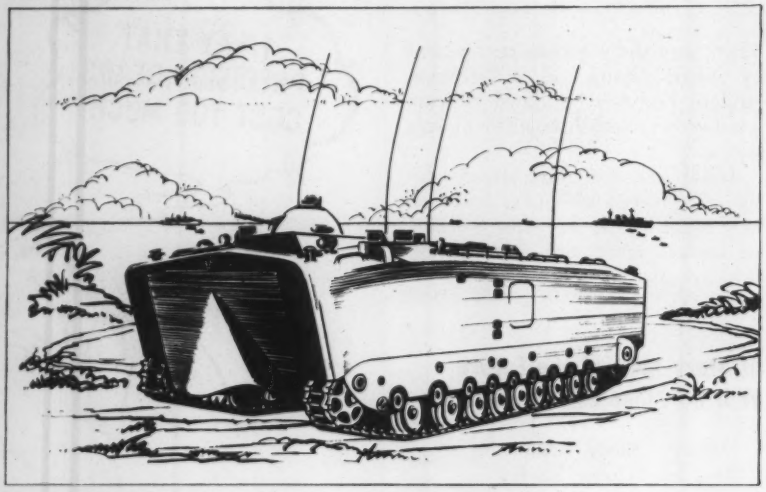
Circle 429 on Page 19



Gas Turbine Powers New Amphibian

A helicopter gas turbine will be the powerplant for the Marine's LVTPX-10, a new amphibious vehicle. The versatile craft being developed by Jered Industries Inc., Hazel Park, Mich., will use a General Electric T58 turboshaft engine. Troop or cargo carrier, or (when fitted with artillery) rolling and floating tank, the vehicle will land 46 fully equipped troops or carry 10 tons of payload afloat or ashore. It measures 29 ft long and weighs 85,000 lb.

Meetings and Shows

Sept. 27-Oct. 1—

American Society of Mechanical Engineers — American Institute of Electrical Engineers. National Power Conference to be held at the Muehlebach Hotel, Kansas City, Mo. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 30-Oct. 1—

Institute of Radio Engineers — American Institute of Electrical Engineers. Industrial Electronics Symposium to be held at the Mellon Institute, Pittsburgh. Further information can be obtained from Robbert H. Delgado, 954 Brentview Dr., Pittsburgh 36, Pa.

Oct. 5-9—

Audio Engineering Society. Annual Convention and Professional Equipment Exhibit to be held at the Hotel New Yorker, New York. Further information is available from Harvey Associates, 580 Fifth Ave., New York 36, N. Y.

Oct. 5-10—

Society of Automotive Engineers Inc. National Aeronautic Meeting, including manufacturing forum and engineering display, to be held at The Ambassador, Los Angeles. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Oct. 7-9—

Gray Iron Founders' Society. Annual Meeting to be held at the Fairmont Hotel, San Francisco, Calif. Additional information can be obtained from society headquarters, National City-E. Sixth Bldg., Cleveland 14, Ohio.

Oct. 7-9—

American Vacuum Society Inc. 1959 National Symposium on Vacuum Technology to be held at the Sheraton Hotel, Philadelphia. Additional information can be obtained from society headquarters, P. O. Box 1282, Boston 9, Mass.

Oct. 8-10—

American Society of Tool Engineers. Semiannual Meeting to be held at the Chase-Park Plaza Hotels, St. Louis. Further information is available from ASTE, 10700 Puri-

LINK-BELT MOTOGEARS . . .

flexible motor selection
durable hardened gearing
available from stock

LINK-BELT Motogears permit smaller spare motor inventory

Motor's down! No time for delay! And no *need* for delay with a Link-Belt Motogear on the job. Pick a motor—*any enclosure—any make*—and switch in minutes. No need to drain oil. As for re-alignment, the rigid bracket makes it automatic.

Design-wise, there's none better. Among its features: oil-tight cast housing; quiet, hardened gears; straddle-mounted pinion that easily shoulders shock, reversing or heavy loads.

Double, triple and quadruple-reduction Link-Belt Motogears are carried in stock. Ratio range: 6.2:1 thru 985:1 . . . up to 100 hp.

FOR FULL-LINE FACTS

on Link-Belt's comprehensive line of speed reducers—contact your nearest Link-Belt office . . . or check and send this coupon to Link-Belt Company for data on all or any combination of the following:

- ☐ gearmotors—Catalog 2747
- ☒ motogears—Catalog 2747
- ☐ helical gear speed reducers—Catalog 2751
- ☐ shaft-mounted speed reducers—Catalog 2618
- ☐ worm gear speed reducers—Catalog 2324-A
- ☐ universal worm gear speed reducers—Catalog 2724
- ☐ parallel shaft speed reducers—Catalog 2619
- ☐ fluid drives—Catalog 2747
- ☐ P.I.V. speed changers—Catalog 2274

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Whenever temperature and performance must go hand in hand SELECT AN RMC THERMOMETER

Available in all scale ranges from −150 F to +1000 F; in dial sizes from 1" to 5"; stem lengths from 2½" to 72" . . . with complete adaptability to any installation

Wherever exact knowledge of temperature is an important part of function, you will discover that there are a lot of good reasons for selecting RMC thermometers.

Suppose for instance that you are designing equipment for low temperature work. You know that an RMC thermometer is hermetically *dry-air* sealed so that no ice coating can ever form on the bimetallic element to stop readings at below freezing temperatures. You can *always* be sure of your low temperature readings.

If severe vibration is a factor, the extra damping of RMC thermometers goes to work to make reading easier, more accurate and to prevent fatigue of the registering element. And when necessary, it can always be easily re-calibrated without opening it or destroying its essential accuracy.

No moisture to freeze the element or fog the dial. RMC thermometers are hermetically *dry-air* sealed then immersion tested for 15 minutes.

No "over" or "under" readings. Re-calibration for extreme accuracy in any range, or necessitated by severe shock, can be done in seconds without breaking seal.

Permanent accuracy with freedom from vibration-caused variable is built in. Silicone damping and special damping bearing minimize vibration and keep shaft alignment true.

Write, wire or phone for catalog and detailed general specifications. If yours is a special application, tell us your requirements. RMC engineers will work with you in solving it.

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REPRESENTATIVES IN ALL PRINCIPAL CITIES

tan Ave., Detroit 38, Mich.

Oct. 11-16—

American Society for Testing Materials. Third Pacific Area National Meeting to be held at the Sheraton-Palace Hotel, San Francisco. Further information can be obtained from ASTM headquarters, 1916 Race St., Philadelphia 3, Pa.

Oct. 11-16—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel, Chicago. Additional information can be obtained from AIEE, 33 W. 39th St., New York 18, N. Y.

Oct. 12-14—

National Electronics Conference to be held at the Hotel Sherman, Chicago. Further information is available from M. J. Jans, Conference Secretary, Armour Research Foundation, Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

Oct. 19-20—

Magnesium Association. Fifteenth Annual Convention to be held at the Hotel Roosevelt, New York. Further information can be obtained from association headquarters, 122 E. 42nd St., New York 17, N. Y.

Oct. 20-22—

American Society of Lubrication Engineers-American Society of Mechanical Engineers. Sixth Annual Conference on Lubrication to be held at the Sheraton-McAlpin Hotel, New York. Further information is available from ASLE headquarters, 5 N. Wabash Ave., Chicago 2, Ill.

Oct. 21—

Cast Bronze Bearing Institute. Annual Meeting to be held at Bedford Springs Hotel, Bedford, Pa. Further information can be obtained from Non-Ferrous Founders' Society, 1607 Chicago Ave., Evanston, Ill.

Oct. 22-23—

National Conference on Industrial Hydraulics to be held at Hotel Sherman, Chicago. Sponsors are Ilinois Institute of Technology and

its affiliate, Armour Research Foundation. Information can be obtained from R. D. Meade, Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

Oct. 25-28—

American Gear Manufacturers Association. Fall Meeting to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from AGMA headquarters, 1 Thomas Circle, Washington 5, D. C.

Oct. 26-28—

Society of Automotive Engineers Inc. National Transportation Meeting to be held at the La Salle Hotel, Chicago. Further information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Oct. 26-30—

Society of Photographic Scientists and Engineers. National Conference and Exhibit to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from society headquarters, Box 1609, Main Post Office, Washington, D. C.

Oct. 27-28—

Society of Automotive Engineers Inc. National Diesel Engine Meeting to be held at the La Salle Hotel, Chicago. Additional information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

Oct. 28-29—

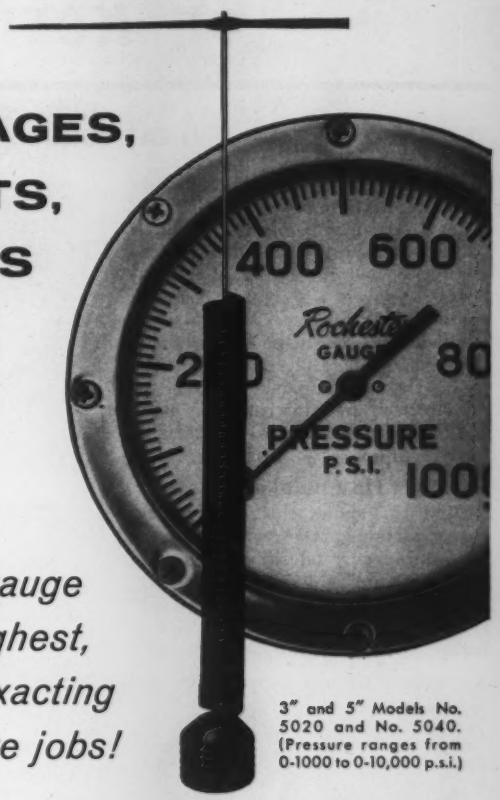
Sixth Annual Computer Applications Symposium, sponsored by Armour Research Foundation of Illinois Institute of Technology, to be held at the Morrison Hotel, Chicago. Additional information is available from M. J. Jans, Conference Secretary, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

Oct. 28-30—

Society of Automotive Engineers Inc. National Fuels and Lubricants Meeting to be held at the La Salle Hotel. Chicago. Further information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Revolutionary New ROCHESTER HIGH PRESSURE GAUGE
has pointer connected directly to pressure element

NO LINKAGES,
NO PIVOTS,
NO GEARS
to wear,
waver
or lag



3" and 5" Models No. 5020 and No. 5040. (Pressure ranges from 0-1000 to 0-10,000 p.s.i.)

This is the gauge for your toughest, your most exacting high pressure jobs!

Now you can practically eliminate maintenance, replacement, and gauge failures—even under the most severe of high pressure service conditions. The new RMC Gauge, models 5020 and 5040, actually approaches the reliability and dependability of the fittings and valves used in pressure equipment.

It is the first pressure gauge to have the pointer directly connected to the pressure element, without linkage or pivots, and with no gears or hair springs.

The pressure element is a multiple turn bourdon coil, to which the pointer is permanently attached at one end. As pressure increases, the end of the coil rotates, moving the pointer with it.

The bourdon coil is made from small diameter tubing. Therefore, the pressure forces against the coil are reduced; the mechanical stress on the coil is less; and spring life, cycling life, overpressure, and endurance are all vastly higher than the conventional "C" type bourdon tube gauge.

For safety, long cycling life and continued accuracy under extreme conditions of overload pressures, high vibration, shock and line pulsation, the new RMC High Pressure Gauge is the one complete answer. Available in pressure ranges from 0-1000 to 0-10,000 p.s.i.; dial diameters 1½", 2", 3" and 5". (1½" and 2" models are eccentric pivot-drive types.)

Write, wire or phone for complete information.

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LIQUID LEVEL TEMPERATURE and PRESSURE INSTRUMENTS

REPRESENTATIVES IN ALL PRINCIPAL CITIES

Circle 432 on Page 19

Design Data on Resilient Clutch Facings

#5

HEAT BUILD-UP IN MULTIPLE-DISC CLUTCHES

A series of tests at the Armstrong Research and Development Center illustrates a common problem in clutch packs with many small plates. Temperatures well in excess of normal operating levels are created near the center of such packs.

Obviously, one of the best methods of reducing operating temperatures is to supply a cooling medium such as oil. However, in many cases this alone is not sufficient to prevent excessive heat build-up.

Results of Heat Build-up

Figure 1 shows this clearly. The spacer plate near the end of the pack (A) shows only oil stains. Temperatures here probably go only slightly higher than ambient oil temperature. However, the center spacer plate is badly blued, indicating temperatures of 500° to 600° F. in the center of the pack. It is estimated that flash temperatures may go over 600° F. The facing near the center of the pack was burned in the tests while the facing at the end was not affected.

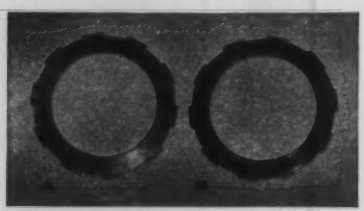

Figure 1. In endurance tests on the Armstrong Clutch Tester, a clutch with two friction plates and three spacer plates, revolving at 1800 rpm, engaged a stationary flywheel. After 5000 cycles at 75 psi pressure and 200° F. oil temperature, the outer spacer plate, A, was not affected. The center plate, B, was blued, indicating excessive heat build-up in the center of the pack.

These studies, conducted on the Armstrong Clutch Tester, used actual production clutch facings and spacer plates. Though the conditions were more severe than normal, similar effects have been observed in current transmissions.

Eliminating Excessive Temperatures

This problem may be solved by substituting a few larger plates for the many small ones, increasing cooling efficiency.

For example, in a single plate clutch, the opposing surfaces constitute a larger mass and act as a heat sump during engagement. And these opposing surfaces also have greater surface area in contact with the oil to dissipate the heat faster after engagement.

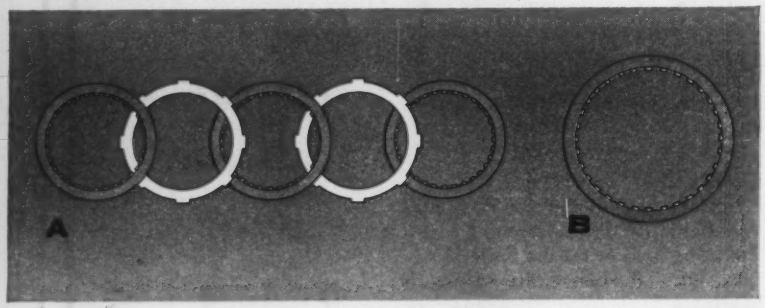

Figure 2. Clutch "A" consists of three faced plates (six surfaces) with facing dimensions of 4" I.D. and 5" O.D. Clutch "B" has one plate (2 surfaces) with facing dimensions of 6" I.D. and 7½" O.D. With equal coefficient of friction and closing pressure in both cases, Clutch "B" has greater torque capacity than Clutch "A."

Effect on Torque Capacity

This substitution of a few larger plates for many small plates can be accomplished with no loss in torque capacity. As shown in Figure 2, a single plate clutch (two facings) with facing dimensions of 6" I.D. and 7½" O.D. has greater torque capacity than a clutch pack with three friction plates (six facings) with facing dimensions of 4" I.D. and 5" O.D. (assuming the same facing material is used under the same closing pressure).

RESILIENT FACINGS LENGTHEN CLUTCH LIFE FOR HYSTER

Hyster lift trucks, designed to handle loads up to 10 tons, are tough on clutches. In the stacking operation, the engine must run at high speeds to operate the hydraulic hoist while vehicle movement is controlled by clutch slippage. This operation, termed "inching," results in severe clutch slip loads.

To lengthen clutch life in heavy-duty applications, Hyster has introduced a new oil-bath clutch (right)

with an Armstrong resilient facing—NC-733 Friction Material.

According to Hyster, this new clutch eliminates heat problems and gives smoother inching and engagement. It reduces maintenance by increasing the life of the facing, the pressure plate, and the flywheel. Hyster reports gains of 1000% to 2000% in facing life since introduction of the new oil clutch with Armstrong NC-733 Friction Material.

. . . . . .

For assistance in selecting the right resilient friction material for your application, send complete details to Armstrong Cork Company, Industrial Division, 7209 Dean Street, Lancaster, Pennsylvania.

Armstrong RESILIENT FRICTION MATERIALS

. . . used wherever performance counts

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Circle 433 on Page 19→

HOW HEAVY A LOAD

can a ball bearing carry?

Federal Ball Bearings make light work of the heaviest loads. *Quiet* work, too. We use SAE 52100 steel and engineer extra stamina into every ball and raceway. Each bearing goes through scores of production and quality control steps because, frankly, we're terrible cranks about precision. We insist that you should be able to mount a ball bearing—and forget it.

Our customers seem to like this idea. And they include the most respected names in American industry. So, when you want to take a work load off your shoulders, put it on a Federal Ball Bearing. Our catalog lists over 12,000 ball bearing sizes, hundreds of types. Send for it.

THE FEDERAL BEARINGS CO., INC., Poughkeepsie, N. Y.

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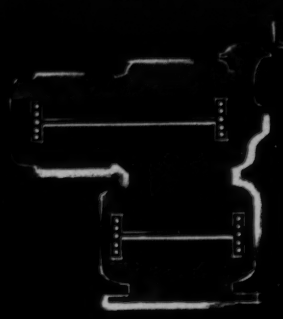
BALL BEARINGS

One of America's largest ball bearing manufacturers

FEDERAL ON FILM—A 16 mm. color sound film takes you through our 400,000 sq. ft. plant. Loaned free. Just ask for it.

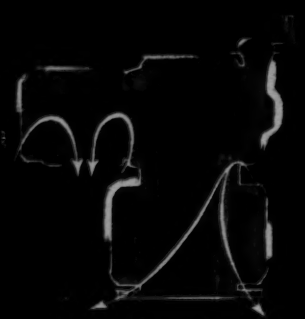
Field Versatility

Mounting feet, end brackets, control hand wheel, conduit box, and output shaft can be relocated in minutes without special tools for wall-, floor- or ceiling-mounting. Components can be changed or controls can be added in the field to meet ever-changing conditions of operation.



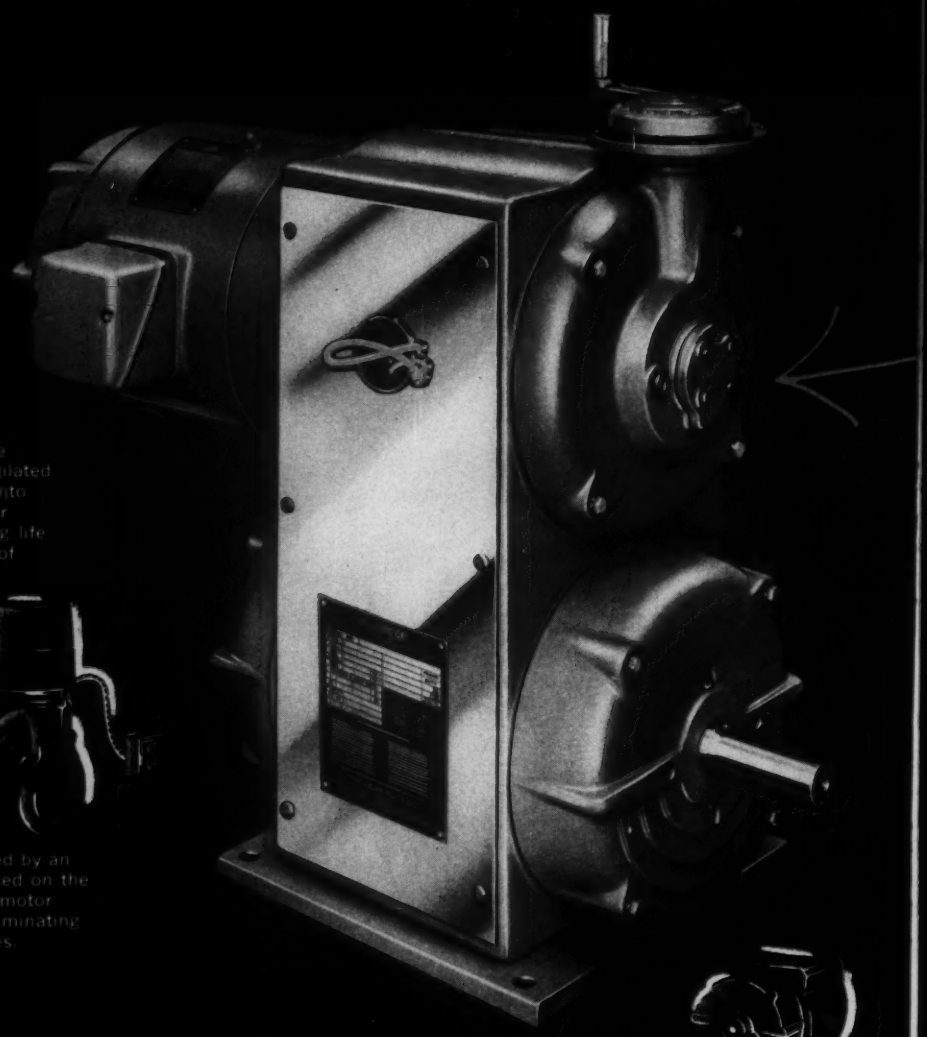
Four-Bearing Design

This important design feature eliminates the problems of overhung discs. It equalizes distribution of belt loading — keeps bearings, shafts, discs and belt permanently aligned — improves performance — and extends bearing life.



Dual-Ventilation System

The motor and the belt housing of the ALLISPEDE DRIVE are individually ventilated. Motor ventilating air is not exhausted into the belt housing — belts run cooler for longer life. Service factor and operating life of all components are higher because of lower operating temperatures.



Trouble-Free Remote Control

Electrical remote control can be provided by an enclosed speed-adjusting motor, mounted on the belt-changing mechanism. This torque motor can be stalled without overheating, eliminating the need for troublesome limit switches.

Long Belt Life

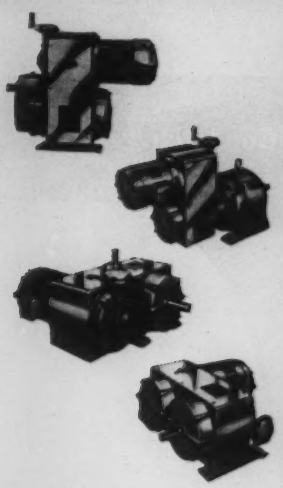
Simple cog belts with extra contact area provide more efficient transmission of power and longer belt life. Dual ventilation, precision machined discs, equalized loading, and automatic belt tension aid in extending belt life.

Fast Belt Changing

Belt changing is fast and easy — without requiring special tools. You remove only one bearing bracket and the speed-adjusting mechanism to make fast changes without affecting permanent alignment of discs or belts.

Remote Speed Indication

A tachometer generator mounted on the output shaft operates an indicator that can be mounted at a remote location. Disassembly of the tachometer is not required when making belt changes.



Four of the many variations of mounting available with the ALLISPEDE DRIVE.

Another new product from Louis Allis

Let's look at the features of the
ALLISPEDE DRIVE*

New Louis Allis Drive offers accurate control – maximum belt life – long-run economy – low-cost versatility – ease of installation

After checking the many superior features of this drive, you will prefer the Allispede every time. The illustrations at the left demonstrate the many advantages of design and construction available in this drive.

The Allispede Drive gives you high efficiency and close regulation. Belt tension adjusts automatically — and belt changes are easy and fast. The modern design eliminates overhung discs—maintains belt and disc alignment — results in longer belt life — provides the ultimate in field versatility.

Check the accompanying features — *now!* A phone call to your local Louis Allis District Office will bring a skilled Louis Allis Field Engineer. He will gladly study your drive problem and offer Application Engineering assistance. Or write to Louis Allis Company, 459 East Stewart Street, Milwaukee 1, Wisconsin for a copy of Bulletin 3600.

*ALLISPEDE is a trademark of The Louis Allis Company.

The Complete Line–

Whatever your mechanical drive application requirements, there's an ALLISPEDE DRIVE to match it exactly. Sizes up to 30 HP, output speeds from 1 to 10,000 RPM, and speed ranges up to 8:1. Motors can be open, drip-proof, enclosed, or explosion-proof; with ventilated or enclosed belt housings, suitable for foot, P-base, C- or D-flange mounting on your machine. Available with parallel shaft, or right-angle, integral gear reducers, special shaft extensions, integral magnetic brakes, electrical or mechanical remote control, and other modifications as required to meet the specifications of your application.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

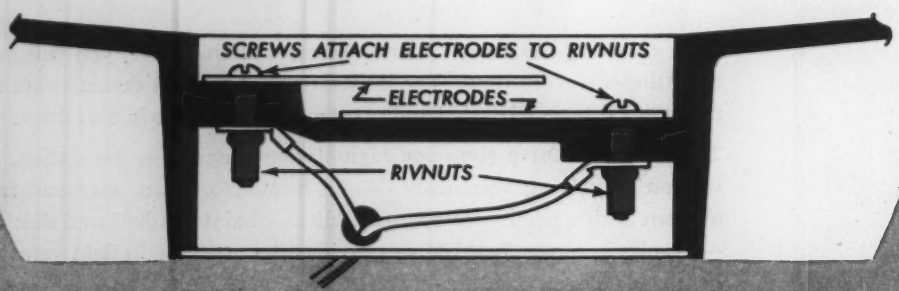
LOUIS ALLIS

Circle 435 on Page 19

A59-131

B.F.Goodrich

B. F. Goodrich RIVNUTS® simplify design, production of Hankscraft sterilizer



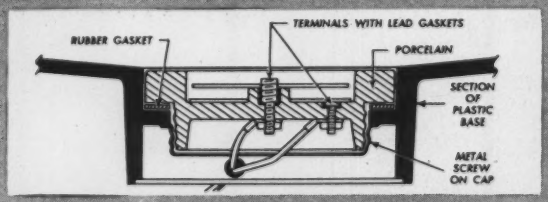
Here's why Hankscraft Company turned to B.F.Goodrich Rivnuts when they streamlined design, production and appearance of the Model 200A Baby Bottle Sterilizer.

Before Rivnuts, the electrodes and terminals were fastened to a large porcelain "dish" by screws and nuts. Four gaskets were required to prevent water leakage. A metal screw-on cap had to be fitted underneath the porcelain "dish". *(See small sketch)*

Rivnuts eliminate all these cumbersome pieces. Installed in the simplified plastic base, Rivnuts secure terminals, provide water-tight nut plates. Two screws attach electrodes — and the unit is complete.

You can get B.F.Goodrich Rivnuts in thread sizes 4-40 to ½"-13 with flat or countersunk heads. Rivnuts have hundreds of applications in appliances, electronic equipment, machinery and structures. Special types are available for aircraft and missiles.

Write now for free copy of the Rivnut Data Book. Better yet, send us a sketch of your toughest fastening problem. *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Akron, Ohio.*



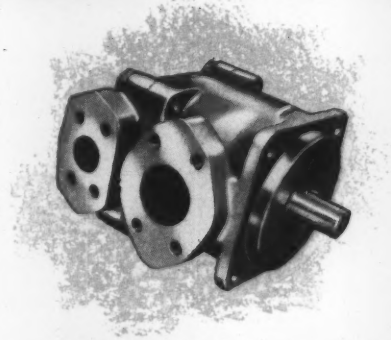
B.F.Goodrich ***aviation products***

VANE PUMP POWER

for

L•TOURNEAU LW WESTINGHOUSE

2000 PSI...BY DENISON



2,000 PSI HYDRAULIC POWER ... is incorporated into dozens of types of earth-moving equipment by leading manufacturers. Denison 2,000 psi hydraulic power gets jobs done faster with dependable trouble-free operation for toughest workloads.

In only 16 seconds, twin hydraulic cylinders raise the body of this Haulpak® off-road hauler to 70° for dumping full loads. To do this day-after-day, The LeTourneau-Westinghouse Company of Peoria, Illinois, takes full advantage of Denison's proven 2,000 psi vane pump hydraulic power. Why? Because *Denison's high, volumetric efficiency is continuous.* There is no drop-off in work speed, no sluggish operation to slow up performance.

And add this: cartridge construction to make in-field servicing fast and simple . . . *all-weather starting* to prevent pump damage. It's your guarantee of less weight, less cost per horsepower and more payload per dollar when a Denison 2,000 psi vane pump powers your equipment.

Have your Denison hydraulic specialist point out how to make your equipment even more profitable to the man who buys it.

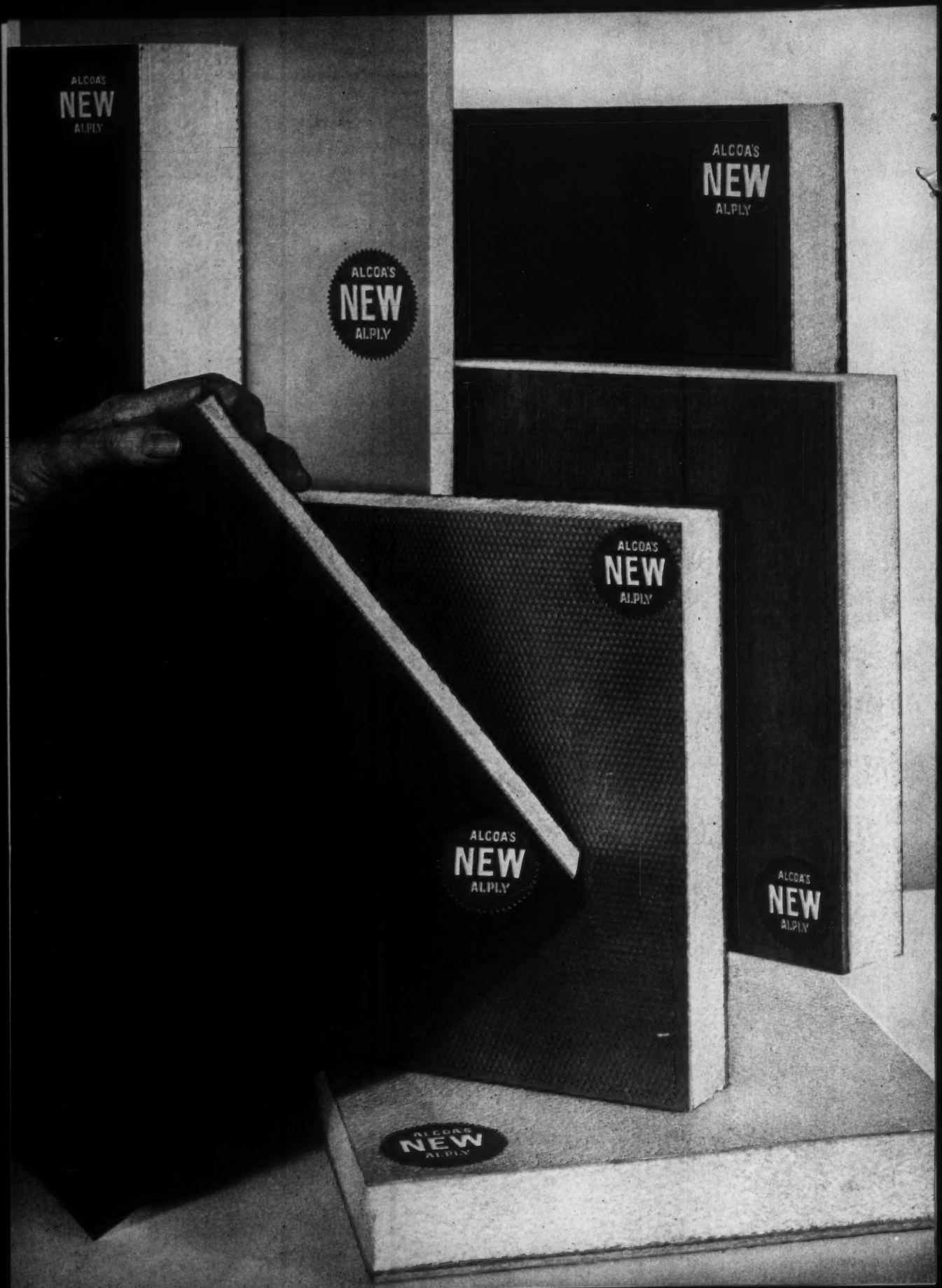
DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

DESIGNERS ENGINEERS . . .
Write for your copy of Bulletin P-9-3 on Denison "T1D" Series Vane Pumps. Includes complete specifications and operating data.

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

DENISON HydrOILics

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS


ALCOA'S
NEW
ALPLY

24 PAGES of new and interesting technical data . . .

YOURS FREE IN *THIS IS ALPLY*

Comprehensive information on Alcoa Alply insulating panels, including physical properties, fabricating and joining data and suggested applications is yours without charge in *This Is Alply*. Here is what this colorful, fact-filled booklet covers:

Comments or questions: _____

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MAIL TO:

Aluminum Company of America
1635-K Alcoa Building
Pittsburgh 19, Pennsylvania

ALCOA ALUMINUM

Types Available — Sketches and descriptions of the types of Alply panels as classified by the outside facing sheet.

Joining Methods—Drawings illustrating the variety of techniques for joining panels, including the use of splines, battens, tongue and groove with aluminum rails and other common fixtures.

Laboratory Test Results—Complete report on cyclic temperature and water spray test, static pressure differential and water spray test, evaluation of insulating values and water vapor test—all conducted at The Pennsylvania State University to demonstrate superior performance.

Thermal and Acoustical Properties—Full data on "U" values for various thicknesses and facing sheets of typical sandwich panels. Results of sound transmission loss test.

Strength Properties—Complete tables of safe values, including bearing stresses and edge compressive load, safe bending moment and transverse shear, deflection and effect of elevated temperatures.

Surface Finishes—Illustrations and descriptions of the wide range of finishes available for interior and exterior uses of Alply panels.

Weather-Resistant Properties — Figures and tables showing the remarkable weather resistance of aluminum facings.

Mail the accompanying card for your copy of *This Is Alply* and your Alply sample

FILL IN THIS FORM FOR SPECIAL SAMPLE

Your Name _____

Title _____

Company Name _____

Street Address _____ City _____ Zone _____ State _____

Your company's principal product or service: _____

What use of Alply do you contemplate? _____

Would Alply replace another material? _____ What material? _____

Does your proposed use involve a new product? _____ Redesign of an existing product? _____

Will color be a factor in your use of Alply? _____

What are your requirements for size? _____ Thickness? _____

Insulation values? _____ Strength? _____

Would you like an Alcoa sales representative to call? _____

Can this sample of ALPLY give you a running start on your competition?

Design horizons are broader than ever since the introduction of Alcoa® Alply insulating panels. Their combination of light weight, strength, stiffness and insulating efficiency—PLUS the corrosion resistance and breadth of colors and finishes common to aluminum—means that imagination imposes the only limits on their use. We produce Alply panel in normal widths up to 48 in. . . . expand its rigid foamed plastic core to provide thicknesses up to 6 in. . . . turn out lengths as long as shipping facilities permit. You can specify aluminum for both facing sheets or substitute plywood, plasterboard, gypsum board or hardboard on one side. Tested procedures for cutting, forming and joining make fabrication simple and economical.

What does Alply's versatility mean to you?

Do low-cost beauty and durability suggest a novel architectural use? Can you capitalize on the opportunity for fast, inexpensive production? Plan a better mobile home? Build a refrigerator or cold room for less money? Redesign a "reefer" car or truck for lighter demands on cooling equipment?

An Alply sample will help you find out

We want to put an actual sample of Alply in your hands so that you can measure its potential against your requirements. We would also like to send you our new, 24-page fact book called *This Is Alply*. You, in turn, can help us appraise your needs if you will tell us about your plans when you fill out the accompanying card for mailing.

Your Guide to the Best in Aluminum Value

ALCOA ALUMINUM

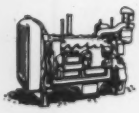
For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

Circle 438 on Page 19

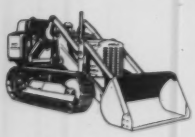
Challenging Engineering Opportunities at CATERPILLAR

be a part of the company building the world's most complete line of earthmoving equipment

Find the satisfaction of *growth* and *stability* within a *growth* company — where imaginative men are creating products for highway construction — industry — farms — national defense — products which build a better world.



Caterpillar offers top ranking Research and Development opportunities — stimulating assignments — professional and personal advancement. You'll associate with the leaders and pioneers in this field — and have at your command the finest equipment, laboratories and development facilities. Please write us, telling all about yourself. Inquiries are confidential, of course.



(Below — New Caterpillar Technical Center presently under construction)

responsible positions available in
RESEARCH — DESIGN DEVELOPMENT

GAS TURBINE LABORATORY
Design, ignition, fuel and combustion systems, etc.

ENGINE DEVELOPMENT LABORATORY
Fuel injection, turbocharged engines, combustion, etc.

VEHICLE COMPONENTS LABORATORY
New power shift transmissions, transmissions, controls, clutches, final drives.

VEHICLE DEVELOPMENT LABORATORY
Quantitative and comparative performance evaluation, soil mechanics, full scale load analysis.

PRODUCT AND APPLICATION ENGINEERING DESIGN
Engines, systems, fuel injection, tractor, transmission, vehicle configuration, earthmoving machinery.

SEND RESUMÉS TO:
John A. Myers — MD-99
Professional and Technical Employment

CATERPILLAR TRACTOR CO.
PEORIA, ILLINOIS

One of the earliest and most basic breakthroughs in fastener design was the common safety pin. And, although DOT is not a manufacturer of safety pins, many a DOT industrial fastener has had an equally revolutionary effect on modern fastening technique. Hundreds of different DOT fasteners have created relatively minor revolutions in specific industries.

A DOT fastener may save a few man-minutes of labor. It may save material. Or it may improve product performance and hence saleability. But multiply each small improvement by the number of units in a true mass-production operation and the savings really pile up to impressive proportions.

Rather than spend your own design staff's time on fastening problems, it might pay you well to call in DOT. You'll have at your service a design and production organization with large-scale facilities for genuine mass-production of special-purpose fasteners and self-fastening devices of all kinds.

Supplementing the Carr Fastener Company are a number of other plants which form the United-Carr Fastener group. They are located in the principal production centers of the United States, Canada, England and Australia. Your nearest United-Carr Field office (see below) is no further away than a telephone call from your desk.

MAKERS OF ★ DOT ★ FASTENERS

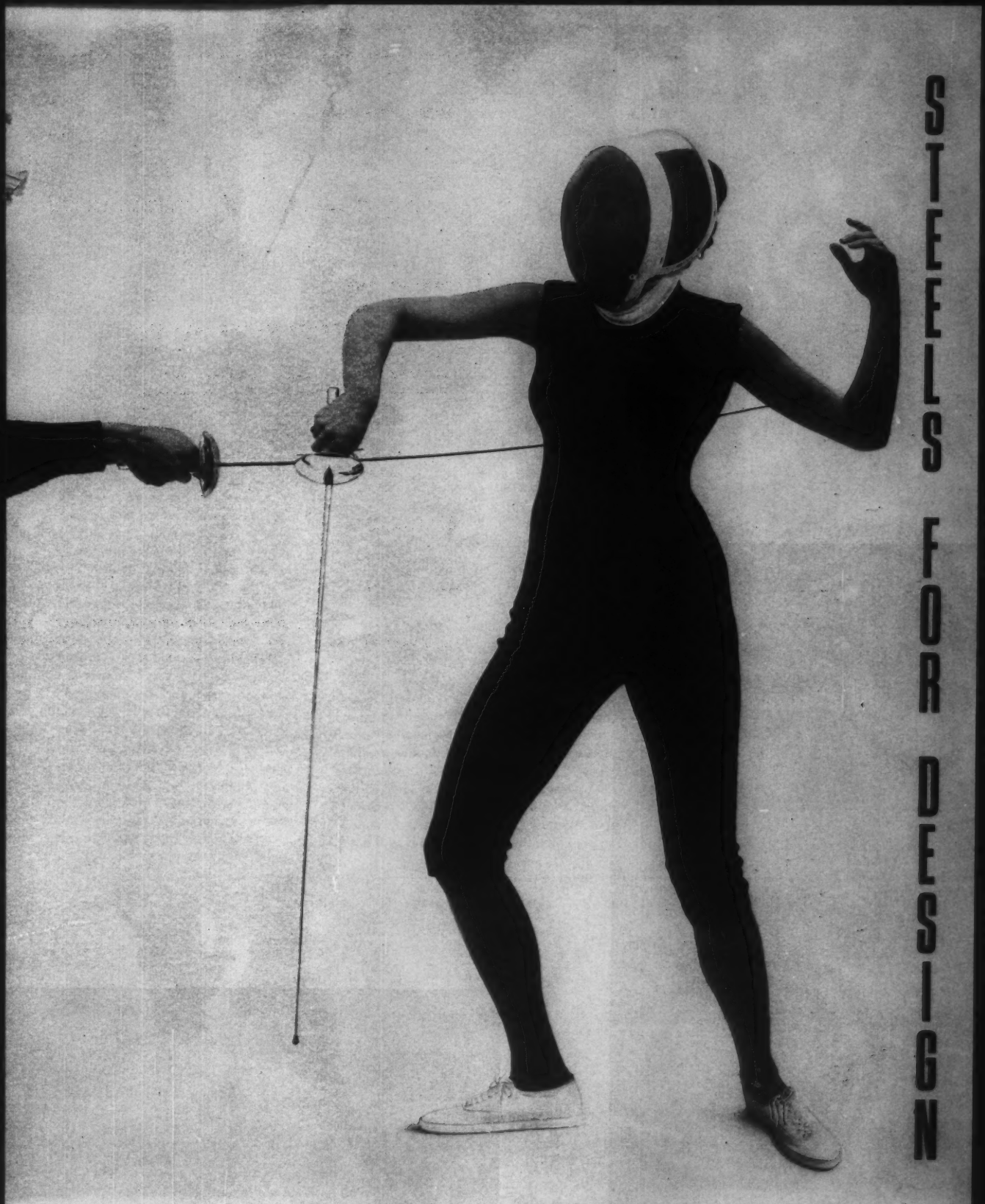
CARR FASTENER COMPANY

Cambridge 42, Massachusetts

Offices In:

Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Los Angeles, New York, Philadelphia, Syracuse

Foils must be light—they must be steel There was a time when your very life depended upon and tough enough to spring back unharmed after countering the intended death blow. These characteristics have



your blade. It had to be as light as human ingenuity could make it. But it also had to be strong,

made steel the most important metal in the history of man. For some modern, lightweight examples, turn the page ▷ ▷ ▷

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

CHAPMAN TRANSPORT INC.

Stainless Steel builds a stronger, lighter trailer. This 40-foot trailer is one of the latest models designed and built by the Fruehauf Trailer Company. It's the strongest, lightest trailer in its class because it was built with Stainless Steel. The Stainless has a yield point of 120,000 psi, almost four times greater than competitive materials, so the walls, roof, and braces could be made thin and very light, yet they are rigid and strong. The exceptional corrosion resistance of Stainless Steel practically eliminates maintenance. This trailer will never have to be painted or refinished and it will still look clean and new after many thousands of miles.

High Strength Steel cuts cable reel weight 25%. The George Evans Corporation is the largest manufacturer of cable reels in the United States. Each of these reels has to carry and protect about $5000 worth of cable—seven tons of it. The reel must be strong and rugged or it will buckle under its load as it bumps over rocks and timbers in the field. It must *also* be exceptionally light, or freight costs will be exorbitant and field handling almost impossible. For a long time, these reels were made of wood and they lasted about two years. Then, the company started to make an all-steel reel, with the rims made of USS COR-TEN High-Strength Low-Alloy Steel. The COR-TEN Steel reels are much stronger and they weigh 25% less than wooden reels. They *cost less*, too, because they cut freight charges; they practically eliminate maintenance; and they will last about twenty years.

USS "T-1" Alloy Steel cuts tanker weight, increases payload. Trinity Steel Company of Dallas, Texas, makes LPG transport tankers and recently the company tripled production to meet the demand for its new, lightweight models. Trinity increased the payload of these tankers substantially by cutting the weight of the carrier itself as much as one-third. They used USS "T-1" Constructional Alloy Steel. Because "T-1" Steel is extremely strong—100,000 psi minimum yield strength—the tank walls are made about ⅓ thinner—with a comparable reduction in weight. And the weldability of "T-1" Steel meets the rigid ASME code that requires X-Ray and magnetic particle inspection of all joints.

USS, "T-1" and COR-TEN are registered trademarks

STEELS FOR DESIGN

United States Steel USS

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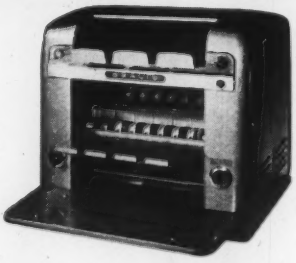
Ozalid "Instant-Copying"

puts design to work ...fast!



Speeds office paper work, too. Table-model Ozamatic has 16" width, turns out up to 1000 copies an hour. Used widely for "one-writing" business systems, general copying. Send for folder No. S-9-17 to Ozalid Division, General Aniline & Film Corp., Johnson City, N. Y.

OZALID DIRECT-COPYING saves time—for the engineer, architect, draftsman—through fast, dependable reproduction of prints. Slashes retracing time when design changes are made. Safeguards valuable originals. Cost? Less per copy than any other copying process! The new Printmaster 1000 (shown above) offers more *useful* speed than any other whiteprinter—up to 100 f.p.m.—gives clear, dry copies in seconds. There's an Ozalid product for every copying need, every budget! Call your local Ozalid representative, or write: Ozalid Division, General Aniline & Film Corp., Johnson City, N. Y.

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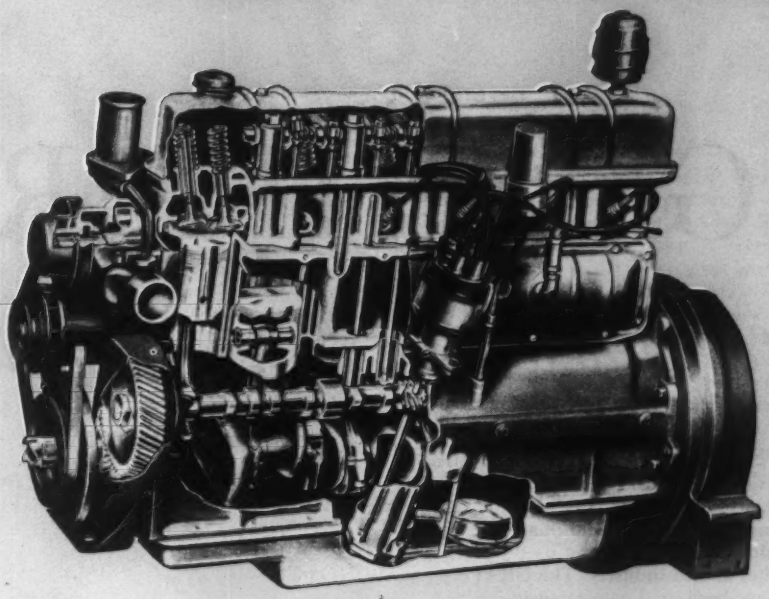
OZALID

Division of General Aniline & Film Corp., In Canada: Hughes-Owens Co., Ltd., Montreal



New UB-220 and UB-264 engines have same high quality construction.

New International downdraft 6's give high product power at low cost

Leading equipment manufacturers are finding a variety of applications for new International UB-220 and UB-264 6-cylinder engines with up to 110 and 148 hp. respectively. This immediate acceptance of these dependable heavy-duty engines is due to four factors: 1) high horsepower developed at lowest cost; 2) outstanding field support by dealer service and parts availability; 3) ease of servicing; and 4) minimum maintenance.

Both engines have these common features: valve-in-head design with downdraft carburetion for maximum power with minimum fuel; reinforced crankcase with full-length water jackets; 100% counterbalanced crankshaft for minimum bearing loads at high speeds; aluminum alloy stepped-dome pistons; gear-driven camshaft for high valve lift, quiet operation and minimum wear; full-pressure lubrication through rifle-drilled passages; large intake valves for free in-flow of fuel-air mixtures; long life exhaust valves with rotators and hard seat inserts; 12-volt electrical system; ball-bearing mounted water pump, full flow oil filter, positive crankcase ventilation with clean air; and easy access to valves, spark plugs, and accessories for simplified maintenance.

For additional product data or any type of installation assistance, call or write International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

International® Construction Equipment

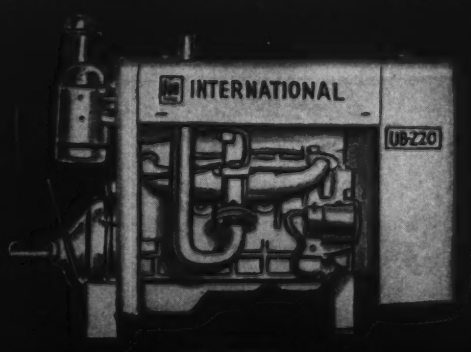
International Harvester Co., 180 North Michigan Ave., Chicago 1, Illinois

A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors... Self-Propelled Scrapers and Bottom-Dump Wagons... Crawler and Rubber-Tired Loaders... Off-Highway Haulers... Diesel and Carbureted Engines... Motor Trucks... Farm Tractors and Equipment.

Circle 441 on Page 19

BRIEF SPECIFICATIONS

Model	UB-220	UB-264
Stripped eng. hp. @ 3400 rpm.	110	148
Indust. eng. hp. @ 2,800 rpm.	83	112
Piston Displ., cu. in.	220.5	264
Bore & Stroke	3 7/16 x 3 11/16	3 11/16 x 4 1/8
Compression ratio	7.5:1	7.5:1
Ind. engine wt., complete, lbs.	815	820



UB-220

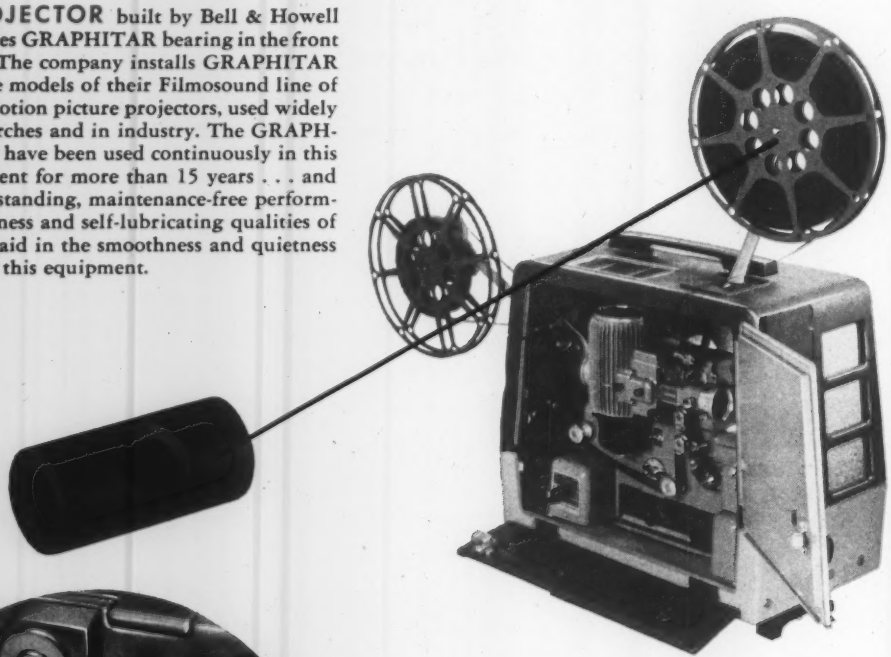
UB-264

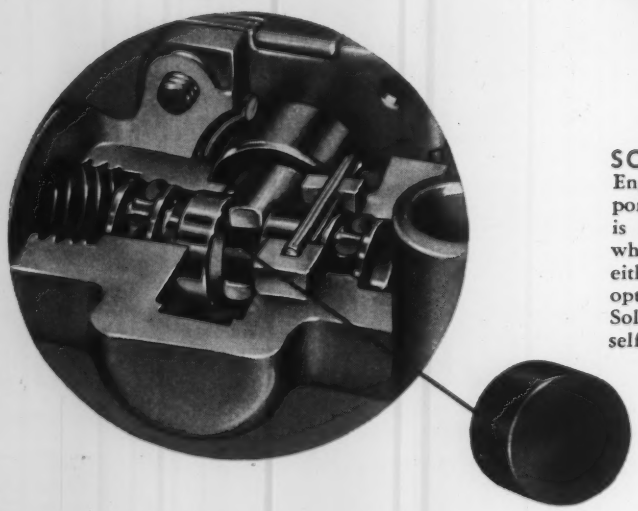
this is GRAPHITAR®

(CARBON-GRAPHITE)

successful in a wide variety of applications

MOVIE PROJECTOR built by Bell & Howell Company utilizes GRAPHITAR bearing in the front reel assembly. The company installs GRAPHITAR bearings in five models of their Filmosound line of 16mm sound motion picture projectors, used widely in schools, churches and in industry. The GRAPHITAR bearings have been used continuously in this line of equipment for more than 15 years . . . and have given outstanding, maintenance-free performance. The hardness and self-lubricating qualities of GRAPHITAR aid in the smoothness and quietness of operation in this equipment.

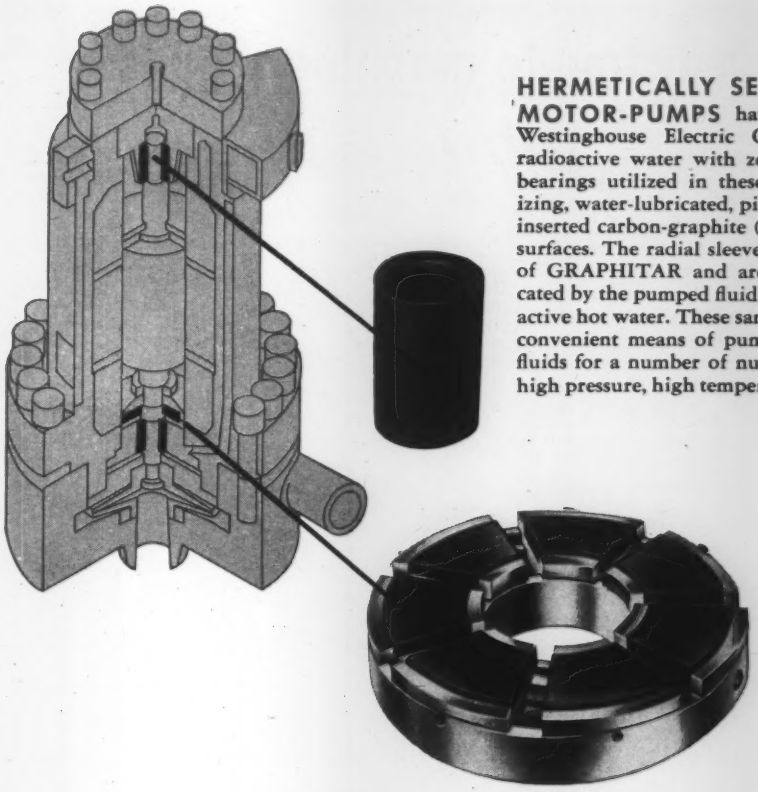




SOLENOID VALVES manufactured by Valcor Engineering Co. for use in guided missiles incorporate a floating seal of GRAPHITAR. This seal is a precise, optically flat GRAPHITAR disc which floats in the plunger. A slight pressure, from either direction, moves the disc against an equally optically flat, stainless steel seat, sealing perfectly. Solenoid valve improves with use due to unique self-lapping action of GRAPHITAR.

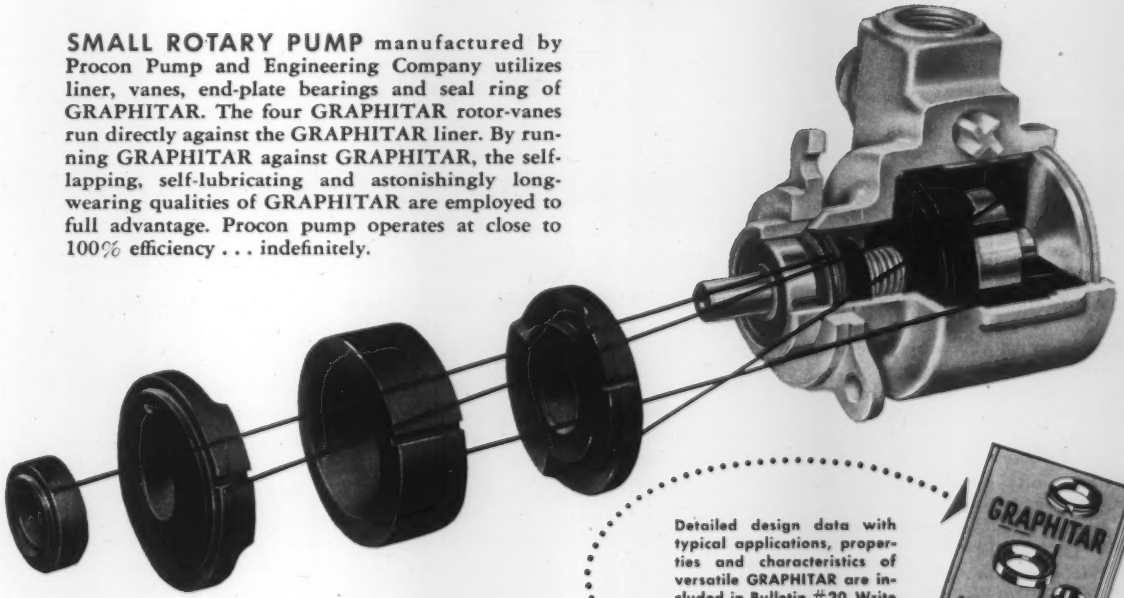
THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



HERMETICALLY SEALED MOTOR-PUMPS have been developed by Westinghouse Electric Corporation to handle radioactive water with zero leakage. The thrust bearings utilized in these pumps are self-equalizing, water-lubricated, pivoted-pad bearings with inserted carbon-graphite (GRAPHITAR) bearing surfaces. The radial sleeve bearings are also made of GRAPHITAR and are designed to be lubricated by the pumped fluid only, in this case, radioactive hot water. These same pumps have proven a convenient means of pumping high temperature fluids for a number of nuclear reactors and other high pressure, high temperature fluid applications.

SMALL ROTARY PUMP manufactured by Procon Pump and Engineering Company utilizes liner, vanes, end-plate bearings and seal ring of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against the GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR, the self-lapping, self-lubricating and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage. Procon pump operates at close to 100% efficiency . . . indefinitely.



Detailed design data with typical applications, properties and characteristics of versatile GRAPHITAR are included in Bulletin #20. Write for your free copy.

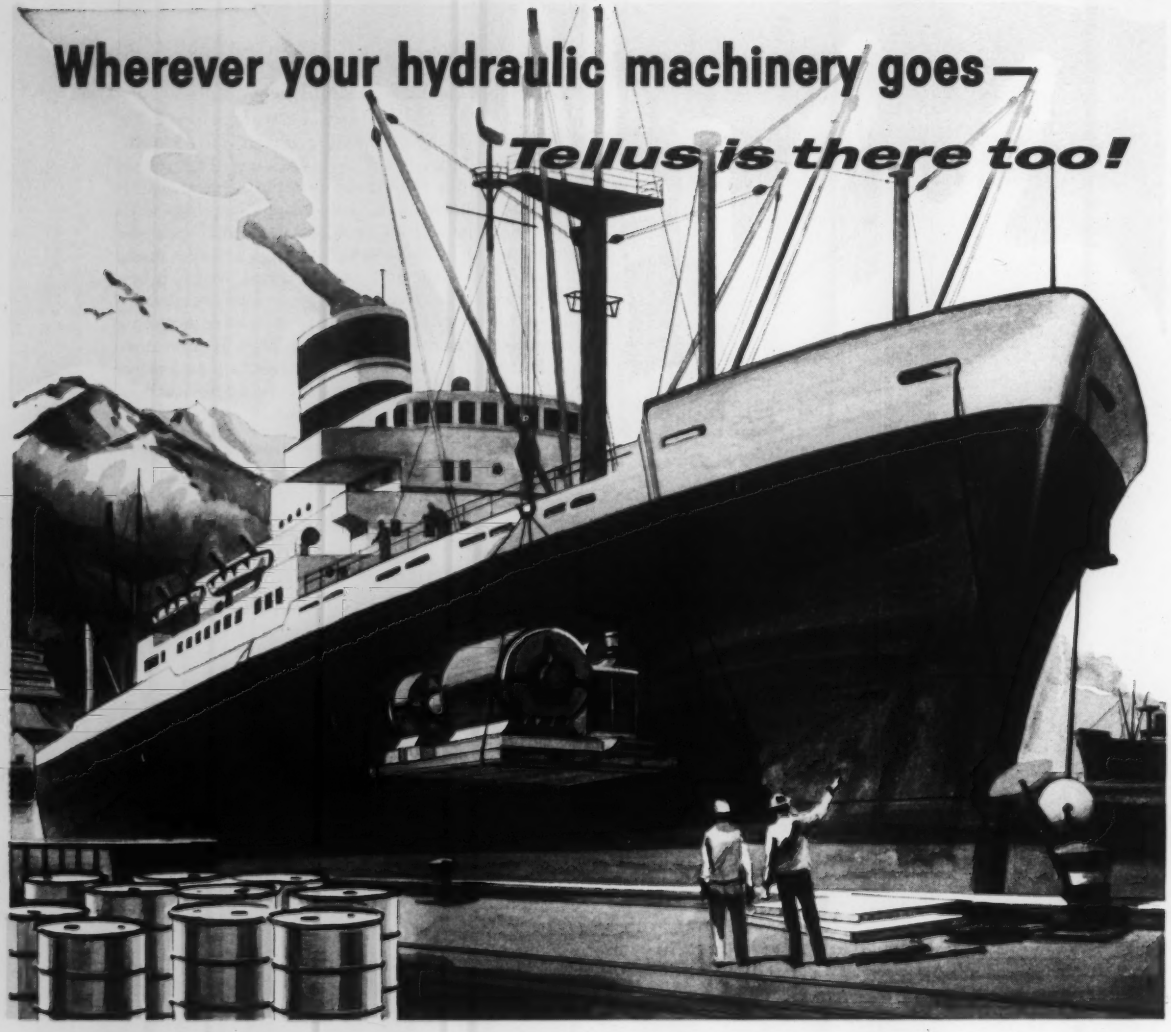
R-265-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

Wherever your hydraulic machinery goes—

Tellus is there too!



Other Outstanding Shell Industrial Lubricants

Shell Rimula Oils—for heavy-duty diesel engines

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Alvania Grease—multi-purpose industrial grease

Shell Turbo Oils—for utility, industrial and marine turbines

Shell Dromus Oils—soluble cutting oils for high-production metal working

Shell Macoma Oils—for extreme pressure industrial gear lubrication

Shell Voluta Oils—for high-speed quenching with maximum stability

Its performance and name are the same around the world

Shell Tellus Oil is available to your customers abroad. Because of this world-wide availability, they can enjoy the same performance that your domestic customers rely upon.

Tellus® Oil is top-rated as both a lubricant and a control fluid for complex hydraulic systems. Its ability to combat oxidation, rust, sludge formation, wear and foaming has earned it world-wide popularity.

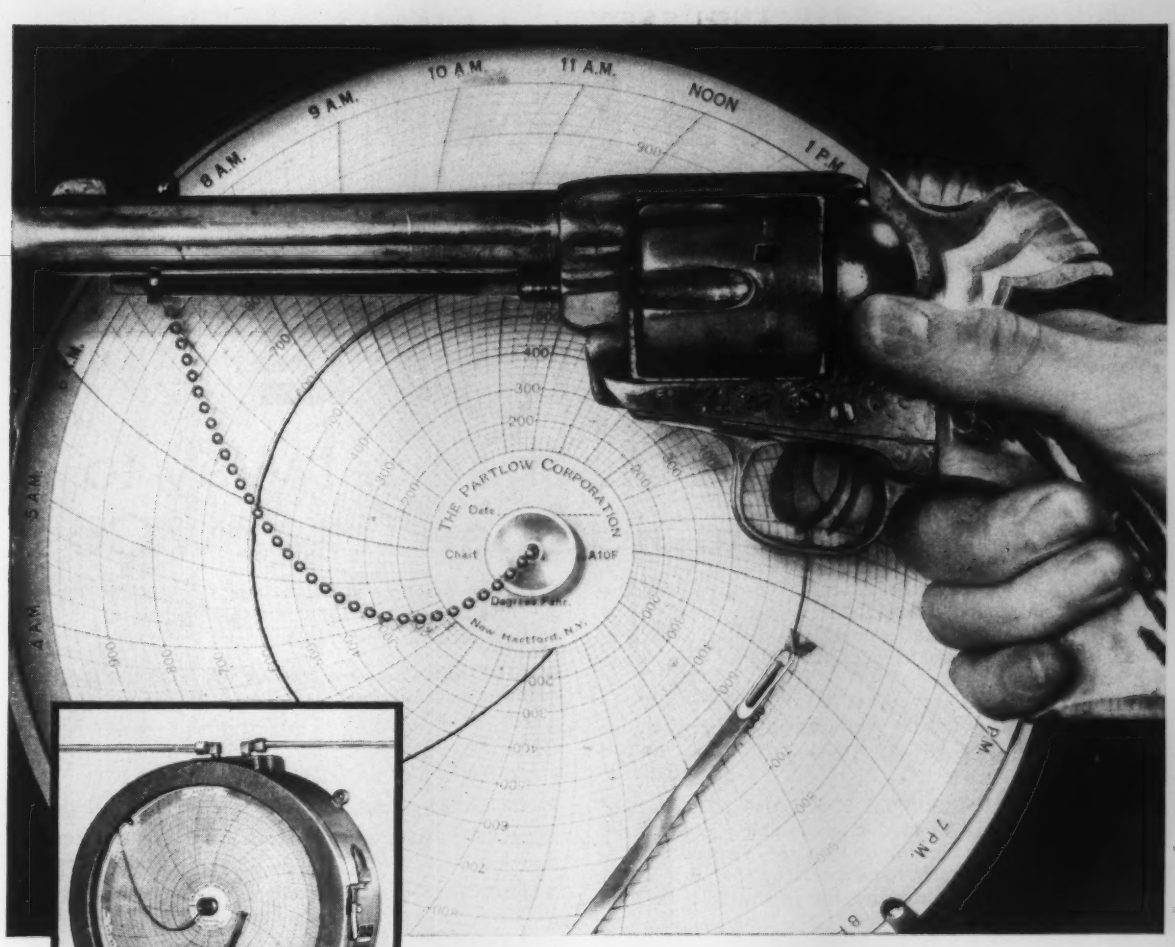
Wherever your hydraulic machinery goes, make Tellus Oil your standard recommendation.

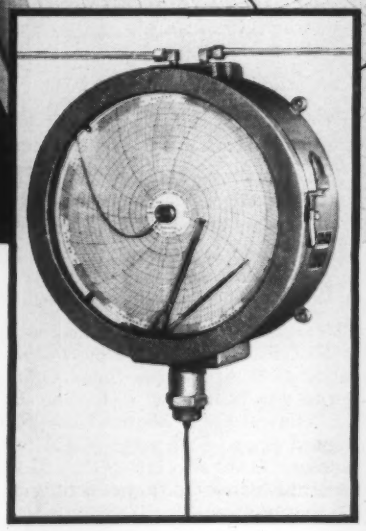
For more complete information, write Shell Oil Company, 50 West 50th Street, New York 20, New York, or 100 Bush Street, San Francisco 6, California. In Canada: Shell Oil Company of Canada, Limited, 505 University Avenue, Toronto 2, Ontario.

SHELL TELLUS OIL

the performance-proven hydraulic oil

SHELL





The Control Geared for

HAIR TRIGGER RESPONSE

even to Fractional Changes in Temperature!

NEW *Recording Pneumatic Temperature Control, Model RVA, available in any of 10 ranges from -30° to 1100° F.*

Extreme sensitivity—reflected in lightning-fast reaction to temperature changes—is a characteristic of *all* Partlow controls. Partlow Recording controls, however, *prove it in writing* . . . You can see for yourself how exceptional bulb sensitivity, teamed with advanced mechanical design, provide a minimum of "saw-toothing" on start-up, and maintain a rigid line of control when temperature reaches a predetermined set point.

Instant response, of course, is just one of Partlow's many built-in advantages. Another is rugged *design simplicity* that does away with hair springs and delicate electronic gadgets . . . that requires no electronic amplification . . . that permits fast, "screwdriver" replacement of the thermal element *right out in the field.*

If you use or manufacture process equipment within the -30° to 1100° F. range, there's a Partlow Pneumatic, electric or self contained gas control to fit your application *precisely*. Recording, indicating and non-indicating models available. For full details write The Partlow Corp., New Hartford, New York, Dept. D-959.

Export: Ad. Auriema, Inc., 85 Broad St., New York 4, N. Y.

You can pay more but you can't buy better than

PARTLOW

TEMPERATURE CONTROLS

Circle 444 on Page 19

GENERAL ELECTRIC ANNOUNCES . . .

NEW POLYDYNE* DRIVE

The Modern Mechanical Way to Obtain Adjustable Speed at Low Cost

General Electric's new Polydyne drives give you low-cost adjustable speed straight from a-c power!

They're compact and versatile—available in configurations and ratings to meet virtually all adjustable-speed requirements!

Polydyne drive versatility is further increased by the number of mounting positions possible, by choice of remote controls, and by speed control and conduit box location.

POLYDYNE DRIVES SUPPLY CONSTANT TORQUE and respond smoothly to load changes. New control design prevents any binding or sticking of speed control mechanisms. All units have been factory and field-tested to help assure dependable operation over long periods of continuous service.

EASY MAINTENANCE. Belt changing is a simple job, and fast! Advanced design reduces possibility of damage to drive shaft and bearings during belt change, and eliminates shaft realignment problems after change.

General Electric Polydyne drives require minimum lubrication, and helical reducer gears can be removed as a unit for easy inspection, service.

Polydyne mechanical adjustable-speed drives can help you boost production by enabling you to:

1. Get the most effective process speed.
2. Get maximum machine life.
3. Adapt machine speed to operator ability.
4. Obtain maximum machine versatility.
5. Synchronize multiple processes.

POLYDYNE RATINGS—¼ to 25 hp, a-c; output speeds 4200 to 5 rpm; frame sizes 1 to 5; speed variations of 2/1 to 10/1 (depending upon frame).

GEAR REDUCTIONS—Single, double, triple and right-angle shaft.

ENCLOSURES—Dripproof and totally enclosed drives.

CONTROLS—Mechanical, manual or remote; electrical pushbutton remote; pneumatic or hydraulic remote.

ACCESSORIES—Remote control with tachometer speed indicator, brakes and slide rails.

CONFIGURATIONS—Upright, horizontal, C, Z, and 45°, geared and non-geared. Non-motorized units also available.

FOR MORE DETAILS and specifications on the complete General Electric PLUS LINE, including Polydyne, contact your nearby G-E Apparatus Sales Office or Distributor, or write for bulletins: Polydyne Drive (GEA-6806), G-E Helical Gear Motor Line (GEA-6704), Shaft-mounted Speed Reducers (GEA-6616), Fractional Horsepower Gear Motors (GEA-6133A), Section 854-1, General Electric Co., Schenectady, N. Y.

*Trademark of General Electric Co.

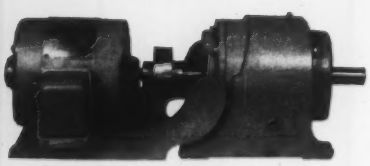
Progress Is Our Most Important Product

GENERAL ELECTRIC

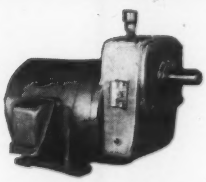
Circle 445 on Page 19

CHOOSE FROM GENERAL ELECTRIC'S **PLUS LINE** OF

Right-angle shaft gear motor



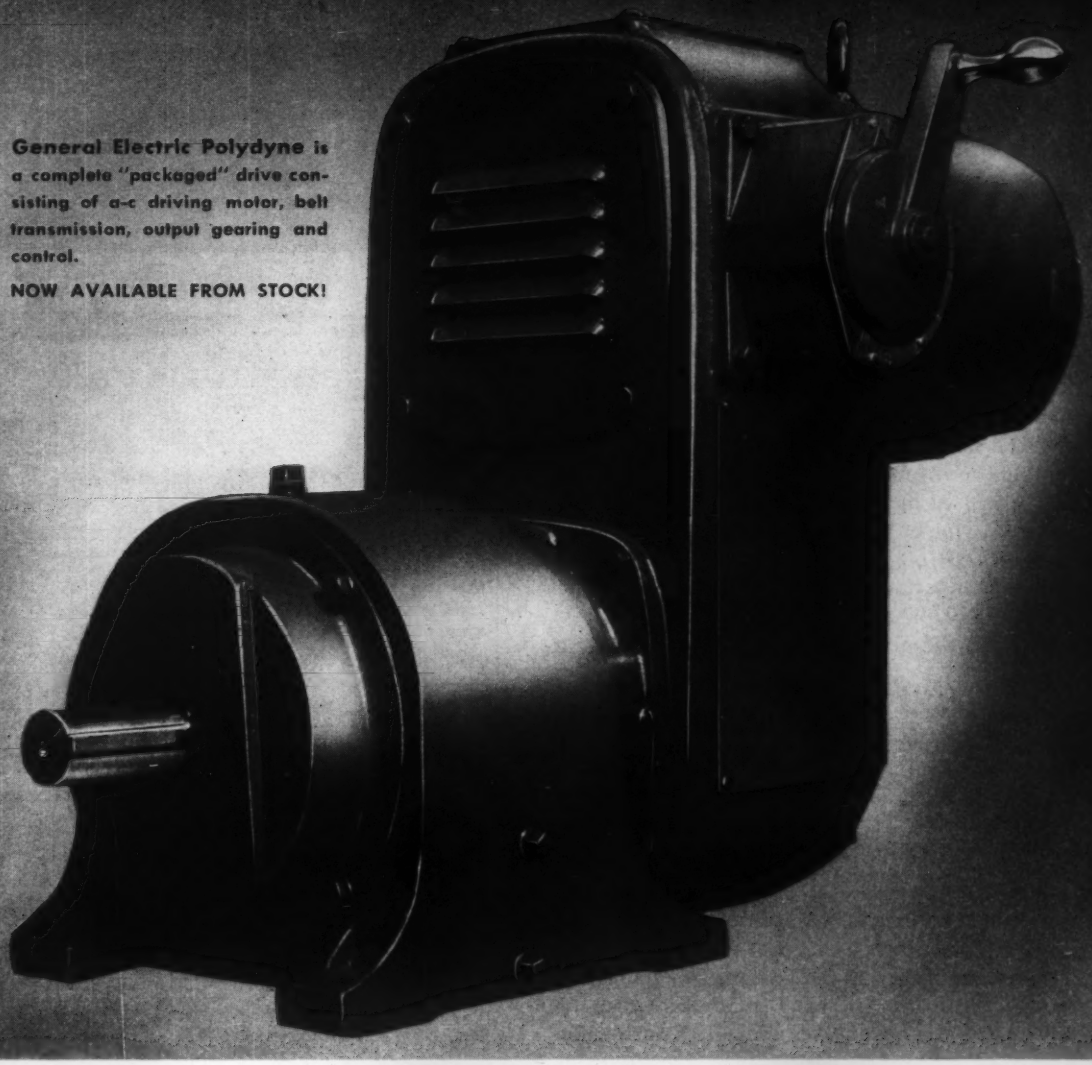
All-motor gear motor



Offset-shaft gear motor

General Electric Polydyne is a complete "packaged" drive consisting of a-c driving motor, belt transmission, output gearing and control.

NOW AVAILABLE FROM STOCK!



You get all these PLUS VALUES with General Electric Mechanical Power Transmission Equipment

1. **Product Application Service.** G-E engineers are available to help you analyze and select the right equipment for your job.

2. **Prompt Shipment.** Offered on all standard General Electric units—from distributor or factory stocks.

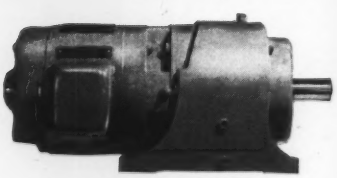
3. **Sales Service.** Your inquiries, quotations and requests for bids are handled promptly by G-E field service offices.

4. **After Sales Service.** 50 G-E Service Shops and 500 authorized Small Motor Service Stations offer expert repair service on all G-E Gear Motor products.

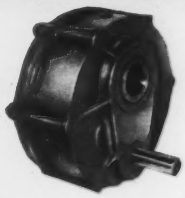
5. **Manufacturer Responsibility.** G.E. focuses manufacturing responsibility at one source, for it produces *all* gearing, components and motors included in its line.

6. **Manufacturer Reputation.** Advanced technology built into G-E mechanical power transmission equipment assures you that it will meet your standards; adds value to and builds preference for your product.

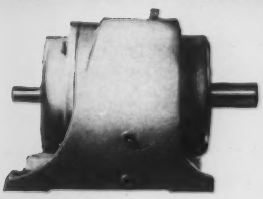
MECHANICAL POWER TRANSMISSION EQUIPMENT



Integral-type gear motor



Shaft-mounted speed reducer



Helical speed reducer

Memo on Metals

Crucible Alloy Offers High Impact Strength, Hardness at 220-240,000 psi Strength Levels

Today's ultra-strength steels possess a unique combination of mechanical properties even when they are used at their ultimate levels of tensile strength. One of the first steels developed in this class — Crucible HY-Tuf® — combines high impact strength, hardness and good ductility at the 220,000/240,000 psi range.

HY-Tuf (1.8% Ni, 1.30% Mn, 1.50% Si, 0.40% Mo) was first widely used in aircraft applications because of its favorable strength-weight ratio. But, because it is also tough and hard, it has rapidly found its way into power-driven garden tools, hand- and power-operated banding machines, rock bit bodies, cutter head bolts, couplings, pinion gears and shafts.

HY-Tuf's high impact strength, especially at high levels of tensile strength or hardness, has been demonstrated in a great number of tests. These tests prove HY-Tuf definitely superior to standard AISI alloy steels in impact strength and ductility at hardnesses above 42 Rc or tensile strengths above 190,000 psi. For specific comparisons, see Figures A and B.

FIG. A—TENSILE AND IMPACT DATA

Grade	Temper	Rc	Tensile Strength, psi	.2% Yield Strength, psi	.01% Yield Strength, psi	% Elong. in 2 in.	% Red. of Area	Izod Impact Ft-Lb
HY-Tuf	550F	46.5	234,000	193,000	154,000	13.1	49.7	31
4340	700	46	228,000	212,000	210,000	11.2	47.8	17
4140	800	46	227,000	205,000	198,000	11.2	39.4	8
9442	700	46	225,000	203,000	200,000	10.3	43.4	11

Oversize .505" dia. tensile specimens and finish machined Izod specimens were oil quenched from the conventional austenitizing temperatures and tempered as indicated.

FIG. B—MAXIMUM IMPACT PROPERTIES
(at hardness of Rockwell C45 or greater)

Grade	Izod			Tension Impact			
	Ft-Lb	Temper	Rc	Ft-Lb	Elong.	Temper	Rc
HY-Tuf	33	400F	47.5	195	16	None	47.5
4340	13	860	45	158	12.2	400F	55
4140	17	500	52	160	14	375	55
8630	19	400	51	148	14	200	52.5
4130 (oil)	17	500	47.5	133	14.5	200	50
4130 (water)	21	450	50	142	13.0	200	52.5

The alloy's superior ductility is shown by these slow bend tests performed on ⅞" rod bars heat treated to 47 Rc.

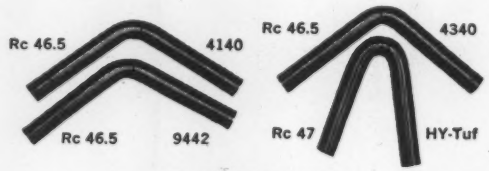
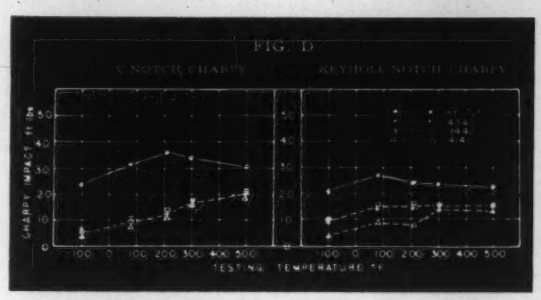


FIG. C—BEND TESTS
Bars — ⅞" rd.

HY-Tuf's notch sensitivity is much lower than that of conventional steels at hardnesses of 45 to 47.5 Rc. Unlike other alloys, HY-Tuf has higher impact values for the V-notch Izod test than for the keyhole Charpy test. This is important because it means that HY-Tuf is much less sensitive to a notch at high strength levels than ordinary steels.

Crucible HY-Tuf conforms to MIL-S-7108 and AMS 6418 and is available in commercial sizes and quantities. For more information on this ultra-strength alloy, send the coupon.

* *ultra-strength steel's impact strength, hardness*
* *titanium price reductions*
* *permanent magnet handbook*



Effect of testing temperature on the notch impact values of HY-Tuf and conventional steels heat treated to 47 Rc.

New Low Prices of Titanium Mill Products Justify Using The Alloy in More Applications

Early this year Crucible's Titanium Division announced new price reductions for its titanium mill products – that cut these prices to *a new industry low*. The reductions, as much as 25%, affected both base prices and the costs of "extras".

For example, sheet was cut from $9.10 per pound base price to $7.75. Strip was reduced $1.25 per pound to $7.25. Plate, formerly $6 per pound, now costs only $5.25. Crucible also slashed billet prices to $3.55 per pound and wire to $5.75 per pound. Bar items were reduced $1.00 per pound to $4.25 (base price). In addition, some size "extras" were reduced as much as 55%, and finished "extras" by over 40%.

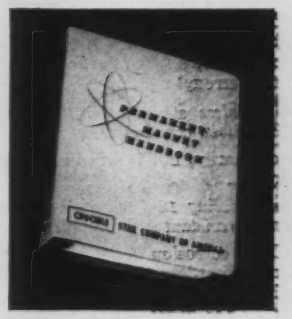
Because of these lower prices, engineers can now utilize titanium's unique properties in many more applications and justify the selection economically. (Even at previous prices, titanium often proved itself the low-cost metal on a cost-per-service-year basis.) This should prove especially true in processing applications requiring corrosion resistance and long-service life, and in aircraft and missile applications where high-strength, lightweight materials are essential.

During the past five years, titanium fabricating costs have also been cut substantially because of experience gained in forging, machining, welding and forming. *For detailed information on Crucible titanium mill products, send the coupon.*

Permanent magnet handbook: 346 pages of design data

One of the most comprehensive manuals ever published on permanent magnets is available through Crucible Steel Company.

The *Permanent Magnet Handbook* contains all the data needed to design magnets into generators, meters, compasses, chucks, couplings, hi-fi and television components, and thousands of other products. It also contains entire sections on permanent magnet measurements, ferromagnetism, magnetization, demagnetization and electro-magnetic theory. It gives the complete performance and property data of over 60 different magnet materials: such as, magnet steels, Alnico alloys, and Ferrimag ceramics.



To cover actual printing costs, a nominal sum of $10.00 is being charged for each copy. However, this sum also covers the cost of additions to the handbook – mailed to subscribers each time new Crucible data become available.

For your copy, send the coupon and check or money order for $10.00. If you are located in Pennsylvania, add 35¢ for state sales tax.

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. E107, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:
Please send me the following:
1. Crucible HY-Tuf Data Sheet ☐
2. Further information on titanium mill products ☐
3. Permanent Magnet Handbook (Enclose check or money order) ☐

Name_____
Title_____
Company_____
Street_____
City_____ Zone_____ State_____

CRUCIBLE STEEL COMPANY OF AMERICA

Circle 446 on Page 19

COOPER ALLOY CASTINGS BRIEFS

THE CASTINGS ANSWER CORNER

Send in your questions on stainless steel castings to Carl Tylka, Cooper Alloy Technical Service Director.

Q. *What can be used for sulfuric acid resistance where FA-20 is not quite good enough?*

A. Cooper 56 or 57 alloys may be used without going to the quite expensive alloy Hastelloy C.

Q. *What is meant by "ferroxyl quality" in evaluation of a stainless casting?*

A. This means a superior surface quality free from pinholes, porosity, scale particles, iron film, grease, or other undesirable conditions, as is guaranteed by passing the ferroxyl test.

Q. *Will stainless steel of the 18-8 type corrode in a moist atmosphere?*

A. Not ordinarily, but it will in contact with graphite.

Q. *Will annealing 12% chromium alloy make it more resistant to corrosion?*

A. No. Best corrosion resistance is obtained in the hardened or hardened and stress relieved condition.

Q. *Is 18-8S MO (316) better than 18-8S (304) for use in hot strong nitric acid?*

A. No, in this particular case 304 is better than 316.

Q. *Is 304 satisfactory for handling 70% sulfuric acid at room temperature?*

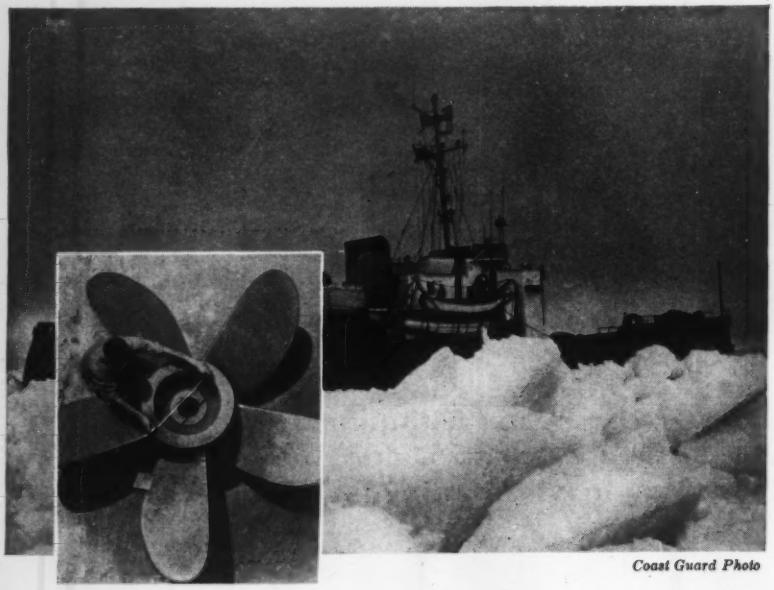
A. No. Believe it or not, carbon steel is satisfactory while 304 is not. If stainless is used, FA-20 must be resorted to.

Q. *Why is it that steel is resistant to 70% sulfuric acid, while stainless 304 is not?*

A. Because sulfuric acid forms an iron sulfate film on carbon steel which is insoluble in sulfuric acid of over 65% concentration, thus protecting the steel from further corrosion. This particular film does not form on stainless, which depends upon passivity for corrosion resistance. In 70% sulfuric acid passivity is lost and the stainless corrodes.

Q. *Is 316 alloy better than 304 for handling hot caustic solutions?*

A. No, 316 has no better resistance than 304 and FA-20. That is why monel is recommended. In extremely severe cases use pure nickel.



Coast Guard Photo

This Cooper Alloy casting helped break the ice for the Coast Guard in a tight situation

The casting is the five-bladed, 8½′ stainless steel propeller shown here. Cast by Cooper Alloy, it is used on Coast Guard icebreakers and buoy tenders like the one shown above in a historic tight situation. Even Washington crossing the Delaware was never subjected to a squeeze like this! This photo shows the Coast Guard buoy tender SPAR during her recent historic threading of the Northwest Passage.

This Passage is the tricky, winding, ice-ridden lane through Arctic waterways above Canada, from Labrador to Alaska. The 180-ft. SPAR and two sister ships made history when they recently completed the first deep-draft transit of the Passage, from west to east. During it, the ships were subjected to the worst ice and weather conditions of many years.

Breakdown under such conditions can mean real trouble. The situation, in fact, is tight in two ways: icewise, for the ship and crew; corrosionwise, for the metal parts exposed to the corrosive-erosive action of the Arctic sea water.

That's why stainless steel was chosen as the metal for the propeller. Sea water is highly corrosive to most metals, particularly as here when high-velocity erosion conditions are also present.

The problems surrounding the casting of a propeller of this size are enormous; but Cooper Alloy has had years of experience in handling just such tricky stainless casting assignments.

Whether your casting is large or small, tricky or straightforward, Cooper Alloy has the know-how and the facilities to do the job, and do it right. If *you* have a stainless part in mind, contact Cooper Alloy Corporation, Hillside, N. J.

Circle 447 on Page 19

Circle 448 on Page 19→

Any way you *Analyze*
Cylindrical Bearing *Values...*

THE LOGICAL CHOICE IS

HYATT *HY-ROLL BEARINGS*

FIVE DECISIVE REASONS

1 QUALITY

HYATT IS THE RECOGNIZED LEADER in cylindrical bearings . . . the pioneer and most respected name in the field for over two thirds of a century.

QUALITY DESIGNED—QUALITY CONTROLLED . . . a rare combination of ultra-modern technology and traditional devotion to craftsmanship, backed by the unrivalled research and production resources of General Motors Corporation.

HYATT HAS THE FACILITIES AND KNOW-HOW to maintain *prototype quality* in *quantity production.*

LOWEST REJECTION RATE of any cylindrical bearing supplier . . . as reported by our customers again and again, almost without exception.

2 PRICE

EXPERIENCED EXECUTIVES know that price is more than first cost. HYATT offers many advantages in quality, assembly practice and uniformity of product that can reduce over-all cost.

BECAUSE OF PRODUCTION VOLUME, in most cases HYATT can provide prices as low, or lower than, other approved vendors. Low first cost coupled with on-time delivery, dependable quality and expert engineering know-how is a difficult combination to beat.

HYATT SALES ENGINEERS can frequently draw upon their experience to make valuable suggestions for cost reduction in bearing applications.

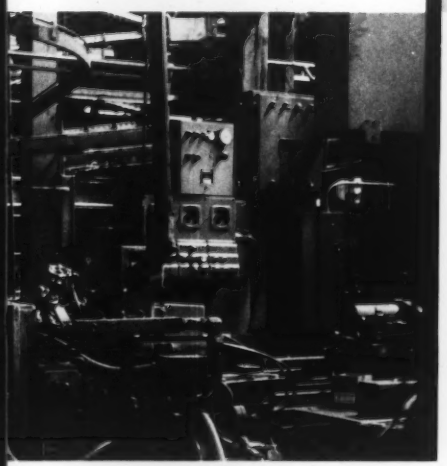
NO BEARINGS CARRY RADIAL LOADS LIKE *CYLINDRICAL*

FOR SPECIFYING HYATT HY-ROLLS

3 DELIVERY

UNSURPASSED PRODUCTION FACILITIES enable HYATT to produce and deliver bearings, in quantity, with maximum speed and economy. Our wide range of product increases the probability that we will have tooling and capacity for even your more unusual requirements.

WHEN SPECIAL BEARINGS ARE NECESSARY, or prototype samples are required, we have the engineering experience, facilities and manufacturing talent to produce them promptly.



4 ENGINEERING

YOU WILL FIND THAT HYATT is usually the preferred source of cylindrical roller bearings with your engineers and designers.

IF YOU ARE NOT regularly specifying HYATT bearings, we believe that closer liaison would acquaint you with the many advantages of designing with HYATT Bearings. Our success with so many customers makes us confident that we can work out a mutually satisfactory program for you.

5 SERVICE

HYATT SALES ENGINEERS are trained bearing specialists whose know-how has saved countless man-hours and dollars for customers in almost every kind of industry.

THEIR THOROUGH STUDY of your individual application problems . . . plus conscientious care in every bearing recommendation . . . is a cost-saving "plus value" which is yours for the asking. We urge you to take advantage of it.

BEARINGS . . . AND NOBODY KNOWS THEM LIKE HYATT

YOU CAN DEPEND ON THE ADVICE OF YOUR HYATT SALES ENGINEER

...and the bearings he recommends!

You get the greatest benefit from HYATT engineering service when a HYATT representative is working closely with you on your bearing requirements. This service is available to you at any time. When you have questions that lend themselves to immediate answers, such as price, delivery or specifications of standard bearings, a telephone call can usually provide the necessary information.

just call your nearest **HYATT** *office:*

HARRISON, NEW JERSEY
427 Middlesex Street
Harrison, New Jersey • HUmboldt 4-4000

CHICAGO
332 S. Michigan Avenue
Chicago 4, Illinois • HArrison 7-8277

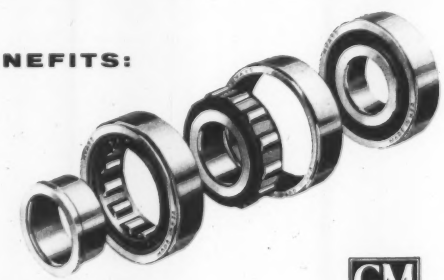
PITTSBURGH
702 Grant Building
Pittsburgh 19, Pennsylvania • ATlantic 1-2927

DETROIT
General Motors Building
Detroit 2, Michigan • TRinity 3-7200

OAKLAND
1419 Central Bank Building
Oakland 12, California • Twin Oaks 3-5362

REMEMBER THESE BUILT-IN HYATT BENEFITS:

- Higher radial load-carrying capacity, size for size
- Minimum space requirements
- Omitted races are optional
- Shaft location without sacrificing capacity
- Easier assembly and disassembly
- Heavier press fits simplify retainment

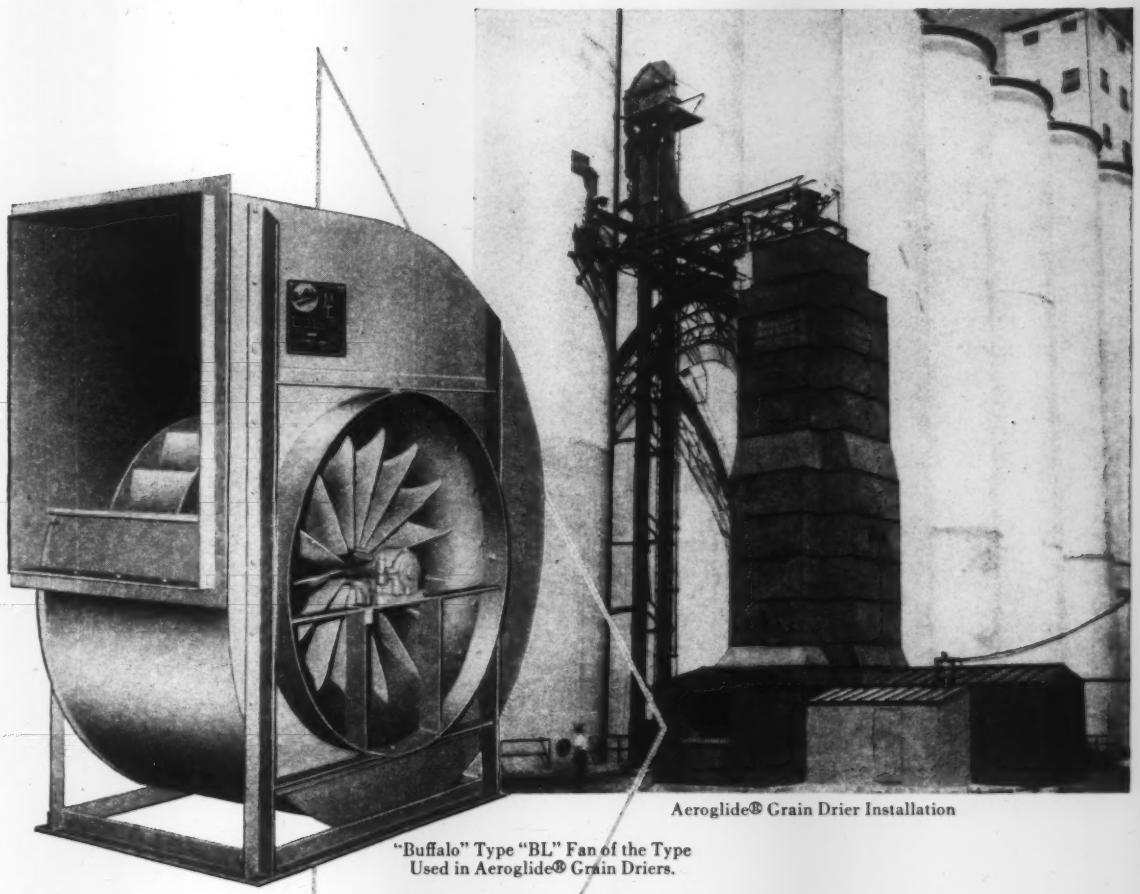


THE RECOGNIZED LEADER *IN CYLINDRICAL BEARINGS*

GM GENERAL MOTORS

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY



Aeroglide® Grain Drier Installation

"Buffalo" Type "BL" Fan of the Type Used in Aeroglide® Grain Driers.

WHY DESIGNERS OF AEROGLIDE® GRAIN DRIERS SELECTED 'BUFFALO' FANS

Aeroglide® Grain Driers are doing an outstanding job in scores of installations throughout this country and abroad. A major feature of the Aeroglide® Drier is the induced draft principle. This has proved most economical, and results in highest quality dried grain. (Corn, oats, wheat, buckwheat, flax, barley, soybeans, lupine and milo.)

Heart of this unique drier is the fan which provides the induced draft. It is logical that Aeroglide® should specify "Buffalo" Fans for this important job. High fan efficiency is required, plus utmost dependability. The "Buffalo" Type "BL" Fans used in Aeroglide® Grain Driers are living up to their world-wide reputation for quiet, economical, reliable, efficient performance.

You can rely on this same high degree of performance and durability in *all* "Buffalo" Fans. The broad and varied line of "Buffalo" Fans of every type and size assures just the *right* fan to perform best on *your* jobs. And, at no obligation, you enjoy the services of competent, experienced "Buffalo" Engineers to help you specify the proper air moving equipment.

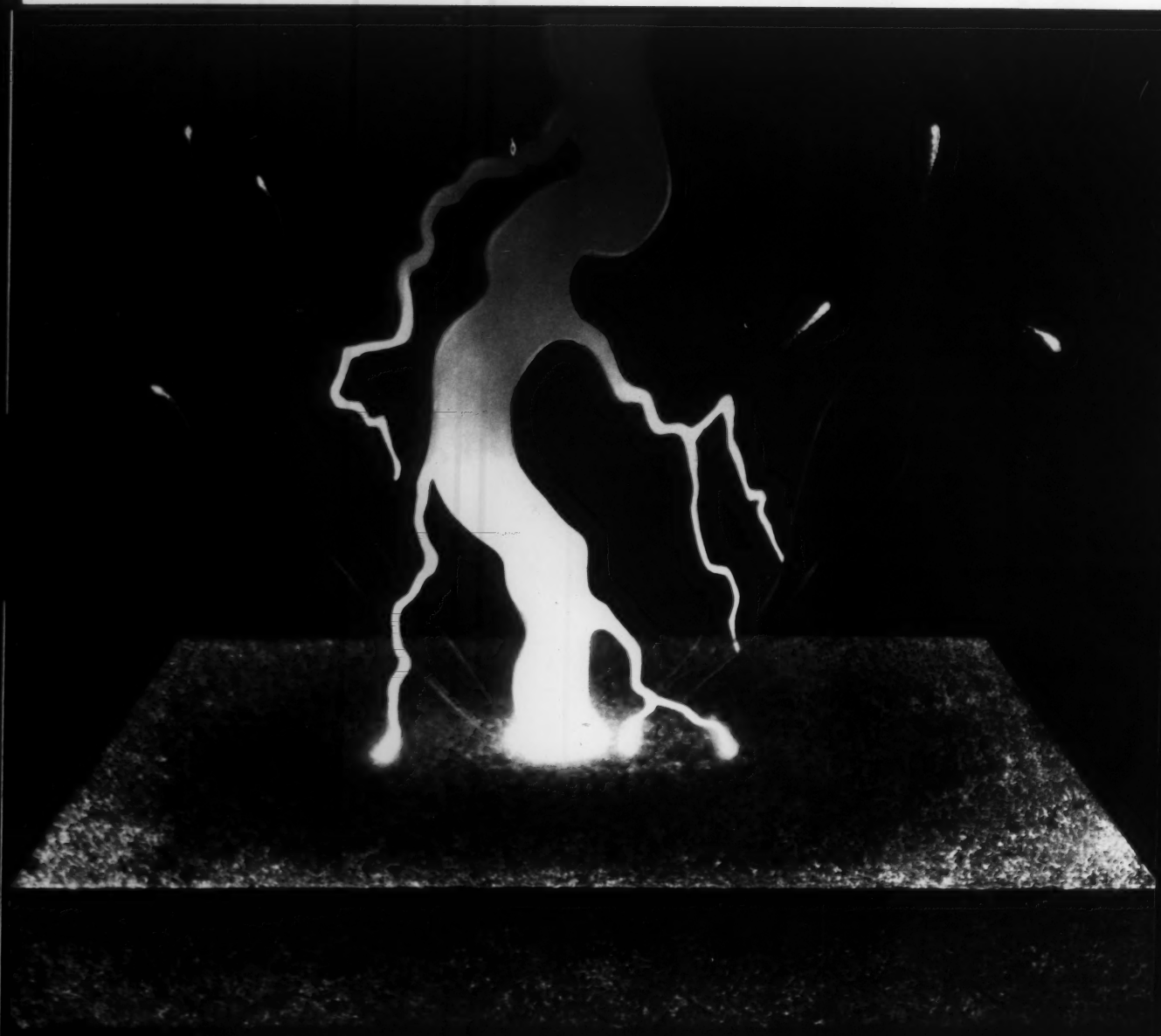
"Buffalo" Fans can be doing a *better* air moving job for *you*. Phone your nearest "Buffalo" engineering representative, or write direct for full information.

Every "Buffalo" Fan brings you the "Q" Factor — the built-in QUALITY which provides trouble-free satisfaction and long life.

BUFFALO FORGE COMPANY
BUFFALO, NEW YORK

Buffalo Pumps Division, Buffalo, N. Y.
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING • AIR CLEANING • AIR TEMPERING • INDUCED DRAFT • EXHAUSTING FORCED DRAFT • COOLING • HEATING • PRESSURE BLOWING



High voltage "lightning" discharge at a Malleable test block.

Toughness is Malleable

Under the slamming, bruising strain of a bulldozer's roughshod ride . . . inside the battering air hammer . . . against the repetitive concussion of a machine gun's smashing action . . . wherever conditions are really brutal, Malleable iron castings prove their ruggedness.

When you're looking for toughness, it will pay you to investigate Malleable castings. Contact one of the progressive firms that displays this symbol—

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

MEMBER
MALLEABLE
CASTINGS COUNCIL

New Malleable Irons Meet Gruelling Service Tests

Toughness is a vital requirement in stressed parts. Each application, however, requires a particular combination of physical characteristics to be sufficiently "tough."

Whatever the specific requirements, one of the finest groups of materials available is the Malleable irons, as illustrated in the tables below.

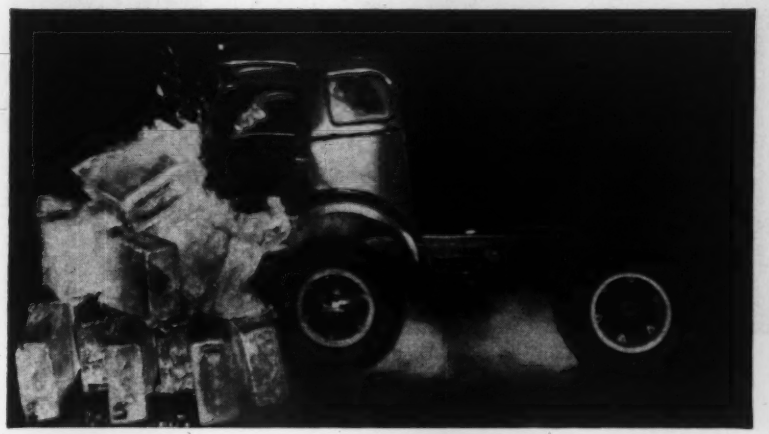
Tensile Properties—A.S.T.M. Minimum Specifications
Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.	Designation	Tensile Strength p.s.i.	Yield Strength p.s.i.	Elongation % in 2 in.
Standard				53004	80,000	53,000	4
35018	53,000	35,000	18	60003	80,000	60,000	3
32510	50,000	32,500	10	80002	100,000	80,000	2
Pearlitic							
45010	65,000	45,000	10				
45007	68,000	45,000	7				
48004	70,000	48,000	4				
50007	75,000	50,000	7				

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Other Mechanical Properties
Standard and Pearlitic Malleable Irons

	Standard	*Pearlitic*
Modulus of Elasticity in Tension, p.s.i.	25,000,000	26,000,000—28,000,000
Ratio of Fatigue Strength to Tensile Strength	0.54	0.40—0.50
Shear Strength—% of Tensile Strength	80—90%	70—85%
Torsional Strength	Approximately equal to Tensile Strength	
Compressive Strength, p.s.i.	200,000	250,000



Malleable's toughness is illustrated in a severe test conducted by a manufacturer of cab-over-engine trucks. To be absolutely sure of the strength and toughness of a variety of components in the cab, including the critical Malleable iron cab support hinges, a truck was crashed at high speed into a barricade of ice. Result—no hinge damage, even though the truck was seriously battered.

Service-Demonstrated Toughness

Highway railing posts demonstrate Malleable castings' use where impact resistance is critical. As an example, thousands of Malleable railing posts line the Connecticut State Thruway. The State Highway Department reports that there have been no failures of the Malleable iron posts although other materials have failed in several cases.

It is also because of Malleable's toughness that so many of the highest quality hand tools are made of Malleable iron. One leading tool manufacturer tests the quality of its pipe wrenches by using a trick well known as the best way to break a wrench. The wrench jaws are put on a rigid bar, a long pipe is slipped on the handle, and the tester heaves his weight downward on the pipe. Because of their confidence in Malleable's toughness, this company unconditionally guarantees every Malleable wrench housing against distortion and breakage. Another hardware manufacturer makes a similar guarantee against breakage on its line of Malleable vises.

But Malleable iron's proven performance in field service is only one reason for its wide use. To this, you must add Malleable's low first cost, design flexibility, and excellent machinability. This combination offers unique advantages over other metals.

Design and Production Assistance Available

To assist in the use of Malleable castings, a special bulletin on toughness—Data Unit No. 105—is available from the Malleable Castings Council, Union Commerce Building, Cleveland 14, O. These bulletins and engineering and planning assistance are also readily available to you from any member of the Malleable Castings Council.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
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Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

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Laconia Malleable Iron Co., Laconia

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Meeker Foundry Company, Newark 4

NEW YORK
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stitching together a giant radome

Radome designed and built by Long Sault Woodcraft Limited, St. Andrews East, Quebec, for the United States Air Force RADC.

Looking upward from the inside of the world's largest stressed skin sandwich radome built of translucent fiberglass panels, securely joined by hundreds of DUAL-LOCK fasteners.

Radar antennae along the upper perimeter of North America's defense system are enclosed by protective domes which stop ice, snow, and gales up to 150 mph.

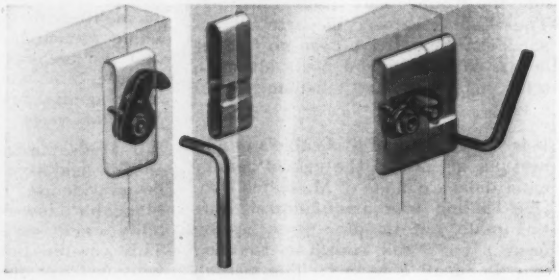
This precisely engineered pattern of fiberglass panels is erected quickly and surely, under the most adverse field conditions, using recessed Simmons DUAL-LOCK fasteners.

DUAL-LOCK is ideally adapted to panel fastening for military shelters, demountable shipping containers, aircraft cowlings and guided missiles.

Features:

- High load characteristics. The standard No. 1 DUAL-LOCK withstands 2500-lb. tension, and with modifications, tension loads of 7000 lbs. and over.
- Double-acting take-up provides great closing pressure, with minimum pressure on operating tool.
- Positive-locking. Trigger action insures fully open and fully closed positions.
- Vibration-proof and impact-proof. Will not accidentally unlock or loosen.

Write for catalog #1257. Complete specifications, drawings, details of DUAL-LOCK and other Simmons Fasteners with unlimited money-saving applications.



SIMMONS FASTENER CORPORATION

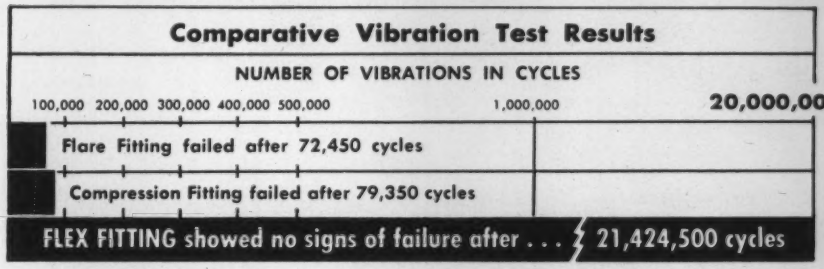
1756 North Broadway, Albany 1, New York

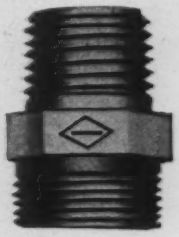
See our 8-page catalog in Sweet's Product Design File

QUICK-LOCK • SPRING-LOCK • DUAL-LOCK • ROTO-LOCK • LINK-LOCK • HINGE-LOCK

IMPERIAL *Engineering and Data File*

ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS





Flex tube fittings withstand over 20-million cycles of vibration without failure

To cope with major vibration in fuel, oil, and vacuum lines serving cars, buses, tractors, trucks, and power units — nonrigid tube connections are preferred. Imperial Flex tube fittings have been proven to withstand over 20-million cycles of vibration without failure! (See bar graph above.)

Such top operating dependability is but one of the money-saving advantages of Imperial Flex fittings. These fittings also eliminate costly flexible hose lines except where there is extensive tube movement.

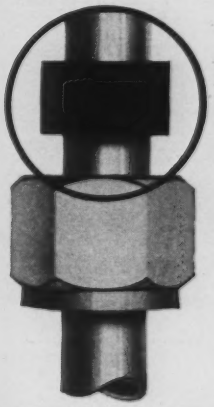
Design engineers point out that tube failure is caused by fracture due to metal fatigue and crystallization — a result of constant shock and vibration. Another cause for failure is tube distortion in making the connection.

ELASTIC SLEEVE — To overcome these and other rigid fitting joint handicaps, Imperial designed an elastic sleeve to cushion and absorb vibration. This special synthetic sleeve permits the tube to flex back and forth while continuing to maintain a positive, pressure-tight seal.

These reliable Flex fittings can be used for connecting all types of seamed and seamless metal tubing: copper, aluminum, thin-wall steel (such as Bundy or GM), Monel, stainless steel, Everdur and many others.

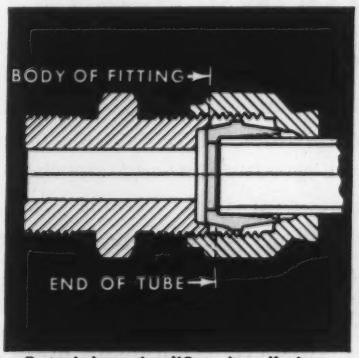
EASY INSTALLATION — To install Imperial Flex fittings for tubing ½" O.D. or smaller, just slip nut and flex sleeve over tubing. Insert tubing in fitting body as far as it will go and assemble. Positive stop nut prevents over-tightening.

Write for Catalog No. 344



No metal-to-metal contact with Imperial Flex fittings! Husky, resilient sleeve (encircled) withstands gas and oil . . . flexes perfectly in sub-zero to 250° F. temperatures. For ⅛" to ⅞" O.D. tubing.

Imperial Hi-Seal tube fitting design offers greater reliability, simplifies installation of hydraulic systems



Butt-joint simplifies installation. Tube doesn't enter body of fitting. It bottoms on shoulder of sleeve. No tube torqueing when making joint.

The superior design of Imperial Hi-Seal tube fittings pays off in reliability, simplified tube connections and reduced assembly time.

With Hi-Seal, the tube *does not* enter body of the fitting — it bottoms on shoulder of the sleeve. No need to spring tubing. Closer tube bends are possible — no flaring or threading is necessary. Joints stay pressure-tight beyond the burst strength of the tubing itself!

Hi-Seal tube fittings are available in brass, steel and stainless steel, for ⅛" to 1½" O.D. tubing. Long dryseal pipe threads are provided on all pipe ends.

Write for Bulletin No. 3061

Hi-Seal conforms to J.I.C., A.S.M.E. and A.S.A. standards.

CONTACT YOUR IMPERIAL REPRESENTATIVE OR WRITE TO:

THE IMPERIAL BRASS MFG. CO.
Dept. MD-99, 6300 W. Howard St.
Chicago 48, Ill.
Please rush me:
Bulletins ☐ No. 344 ☐ No. 3061

Name .....
Title .....
Company .....
Street .....
City ..... Zone .... State .....

IMPERIAL

THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 48, Illinois
In Canada: 18 Hook Ave., Toronto, Ontario

fast!

...680 units per minute!

"Gunner" Don Lang, "zeros in" on top profits for our customers with his high-speed Flexopress ripping out machine-gun bursts of 680 component parts per minute.

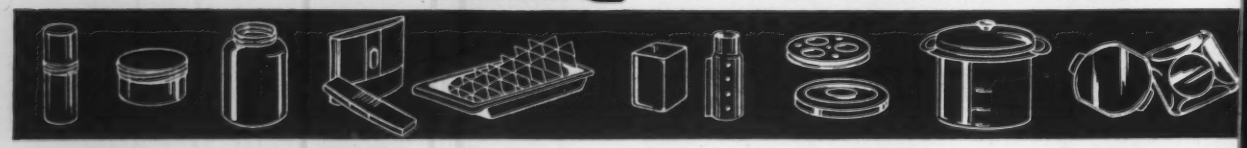
Actual action photo taken by stroboflash

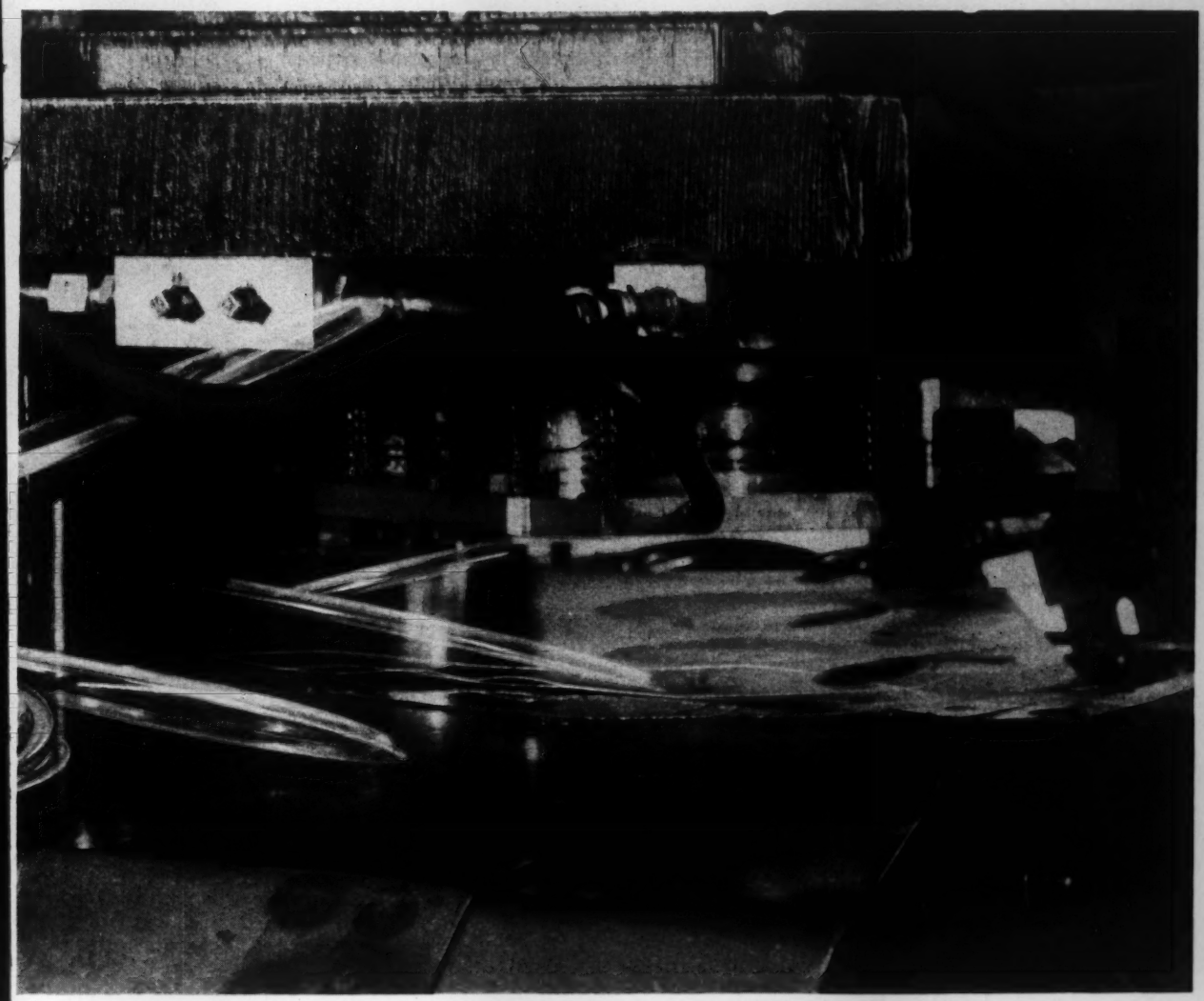
automatic

Speed plus accuracy equals low-cost volume.

That's the formula for success in component part production *and* purchasing, because you only benefit from quantity buying when you have a source that's set up for *quantity* and *quality* production.

We have high-speed equipment unduplicated anywhere in America, that can



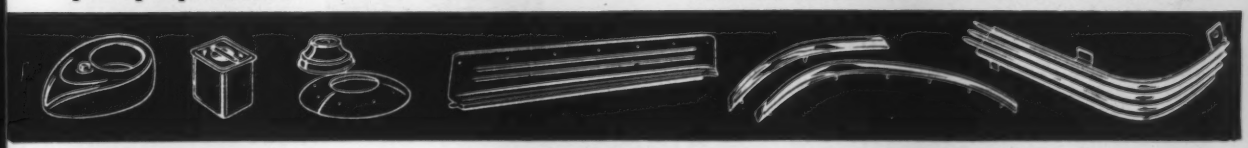


weapon...peacetime style!

be tooled to your job, if your job can absorb real quantity runs. The resultant saving is what we call "pushbutton profit" for you, the buyer. It comes from *automatic* operation, making thousands of units every hour of the run.

If "pushbutton profits" appeal to you and pushbutton methods can be applied to your job, send us your inquiries, for prompt quotation.

MIRRO ALUMINUM COMPANY
(Formerly Aluminum Goods Manufacturing Company)
MANITOWOC, WISCONSIN
FIFTH AVENUE BLDG., NEW YORK 10 • MERCHANDISE MART, CHICAGO 54



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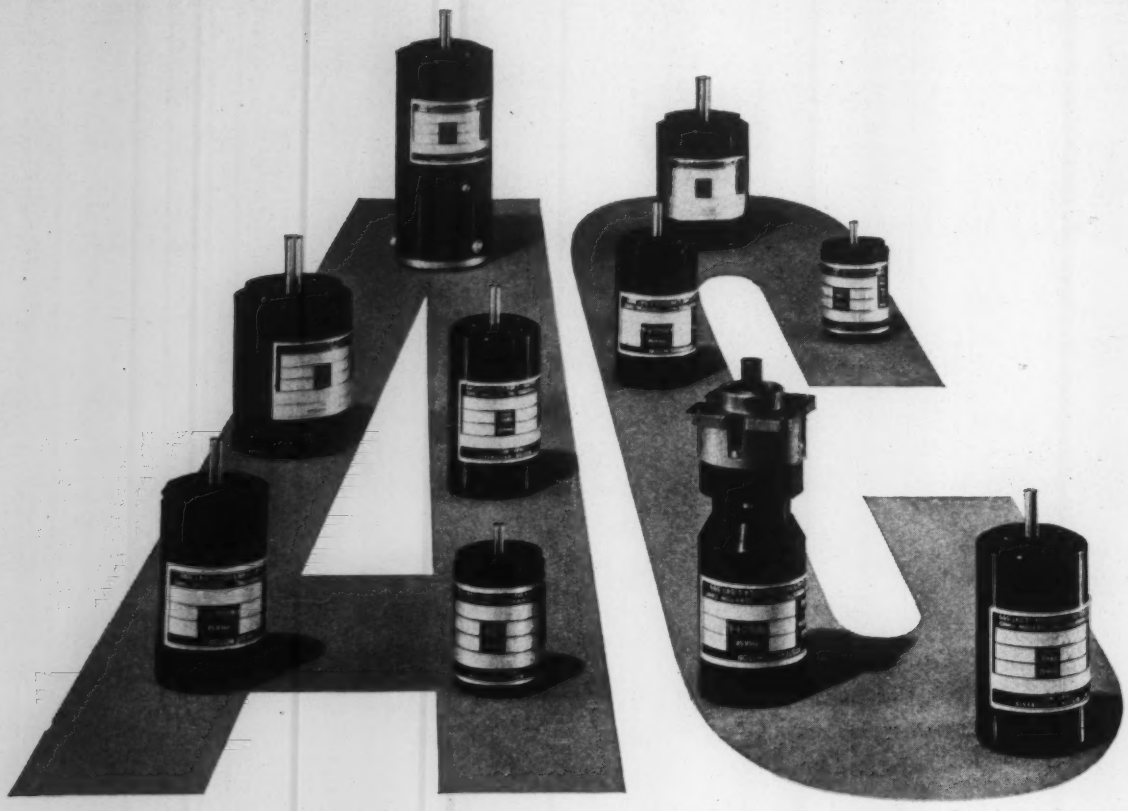

SMALL A. C. MOTORS

Consider the many advantages of using precision miniature a.c. motors. Output performance equals that of larger conventional motors—so you can offer smaller, lighter, more compact designs than your competitor. And you can offer superb reliability. When you design around precision miniature motors, their price in quantity is competitive with larger ordinary motors. Globe is the largest precision miniature motor specialist and is working with people like you right now to gain these benefits.

Get in touch with Globe early in the design stage. Very probably Globe has already made a motor close to your requirements. You'll receive a recommendation for your specific job, and get custom prototypes promptly.

Globe's induction and hysteresis-synchronous a.c. motors provide up to 4.5 oz. in. of torque—up to 200 in. lbs. with a planetary gear reducer! Sizes start at one inch in diameter, and can include such special features as integral brakes, clutches, speed reducers, etc. Please request Bulletin ACM. GLOBE INDUSTRIES, INC., 1784 Stanley Avenue, Dayton 4, Ohio. BAldwin 2-3741.

GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS, TIMERS, GYROS, STEPPERS, BLOWERS, MOTORIZED DEVICES

GLOBE

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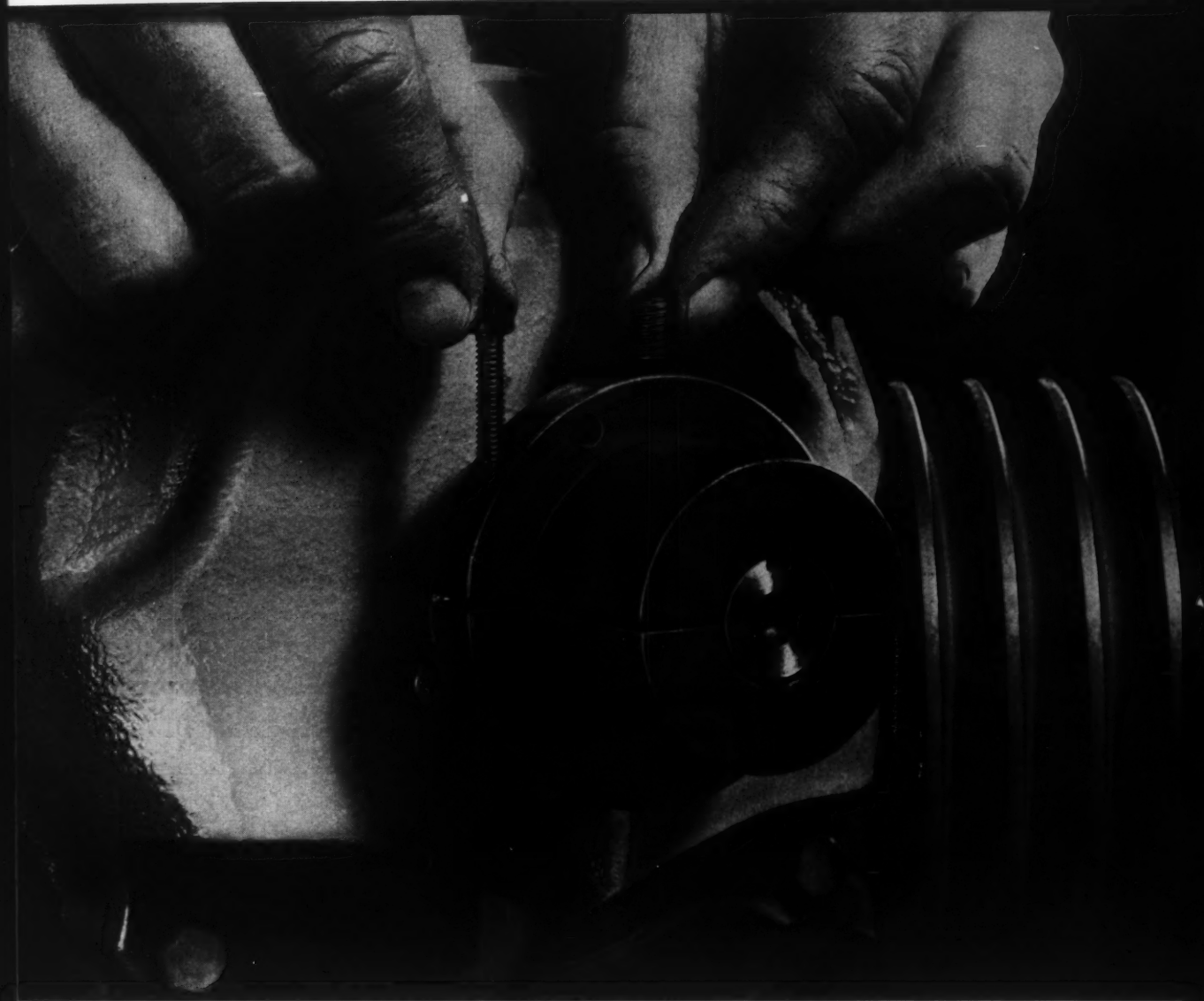

Announcing Worthington QD Sheaves with the

GOLDEN SCREWS

To demonstrate to you that the exclusive two-screw design is practically worth its weight in gold, all Worthington QD (Quick Detachable) sheaves now have two golden screws.

The clamp screw simplifies installation and assures permanent alignment. You can install QD sheaves one part at a time. No heavy rim and hub combination to delicately inch into place. You just slide the hub on the shaft and permanently lock it in position with the clamp screw. Then you slide the sheave rim into position on the hub. This job is simplified because you engage the large end of the sheave with the small end of the hub. To change speed you simply install another sheave on the hub which remains anchored to the shaft by the clamp screw.

The set screw prevents "key drift." It locks the key securely in place, avoiding the danger of the key drifting off and becoming a safety hazard. This feature is appreciated by plant operators who first brought this potential danger to Worthington's attention.

You tighten the set screw without distorting the hub. The clamp screw allows you to locate the hub on the shaft. The locked hub then permits you to tighten set screw on key without distortion.

You can get Worthington QD sheaves anywhere in the U.S. More than 350 distributors carry Worthington sheaves and Worthington-Goodyear Green Seal V-belts. For your copy of a 100-page Multi-V-Drive Manual on how to select the right sheave and V-belt write to Worthington Corporation, Section 79-15, Oil City, Pennsylvania. In Canada: Worthington (Canada) Ltd., Brantford, Ontario.

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WORTHINGTON

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

Quick facts on cold heading

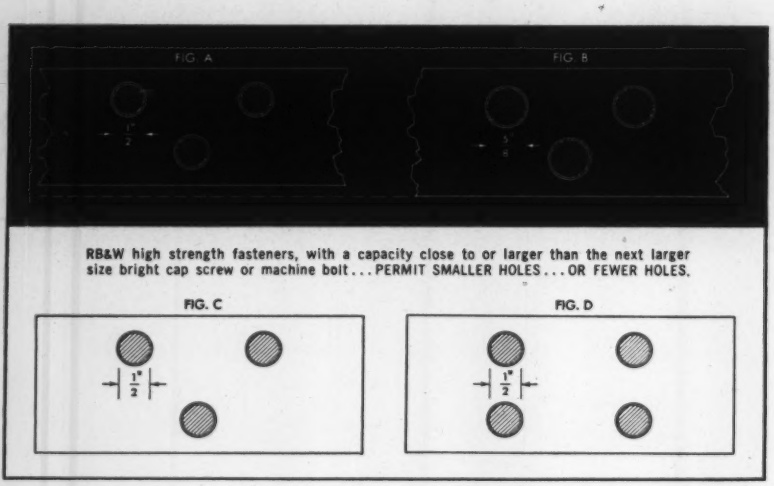
Compared to machining, cold heading gives stronger pieces at less cost. Also, the headers automatically control quality because unsound material cannot be used. While the scope of cold headers is wide indeed, it pays to design for them right at the start.

Some rules of thumb to guide you:

1. You save money after a run of 25,000 pieces (which pays for the set-up).
2. Maximum length of parts runs about 6 inches. Maximum volume of upset is equivalent to length of stock 4½ times its own diameter. (With special operations, up to 26 diameters have been achieved!)
3. Various metals and alloys are suitable. But keep carbon content in steel to under 0.45.
4. Concentric pieces are easier to form, though eccentric and serrated shapes are practical.
5. Avoid sharp corners. Allow generous radii.
6. Because upsets are usually cylindrical, oval or round shapes take less trimming than square or rectangular.
7. Hollow upsets tend to form cracks at edges of recess, so avoid them.
8. Embossing raises costs.
9. No problem heat treating short sections. But long sections are apt to be distorted.

When in doubt, contact an expert in cold heading.

How high strength fasteners affect the holes they fill



As simple a matter as the selection of fasteners can permit changes for better design ... and also improve production costs and service life.

In sketch "A", for example, you see one difference from use of RB&W high strength fasteners instead of machine bolts or bright cap screws, as in "B". You use a smaller size fastener. Holes are therefore smaller. The metal section, in turn, can then be smaller for a saving in material and weight. The costlier the materials (copper bus bars as a case in point), the more significant the cost savings.

In sketch "C", fill the 3 holes with ½" high strength bolts, and you have a load capacity close to 40,000 pounds. That's the same as developed by 4 bright cap screws filling holes in Sketch D. It costs less to drill and less to fill the 3-hole design.

RB&W High Strength Fasteners are now identified by this new marking as well as 3 radial dashes. They have the proper balance between ductility and hardness required in high carbon units.

EFFECT ON PERFORMANCE AND PRODUCTION

When tightened to their full load, high strength fasteners not only *stay* tight—even under vibratory conditions—but also exert high clamping force. It has been shown that, under high compressive forces, hole areas gain extra resistance to fatigue cracks.

What's more, the high friction developed virtually locks members together, prevents slippage. Holes, therefore, need not be perfectly aligned since they can even be slightly oversized without detriment.

There's an RB&W Fastener Man ready to aid you in working with high strength bolts — in the design stage or as replacement for SAE grade 1 or 2 steel fasteners or for rivets. Write for helpful booklet DC-1, Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Circle 456 on Page 19

NEW *from* SEALMASTER®

- Precision self-aligning one-piece unit. No extra assembly costs for you.
- Malleable housing provides maximum strength with lightweight.
- Permanently sealed — prelubricated with high grade lubricant.
- Nothing of comparable value in low price field.
- Reversible for flush or recessed mounting.

SEALMASTER BEARINGS
A Division of STEPHENS-ADAMSON MFG. CO.
18 RIDGEWAY AVE. • AURORA, ILL.

Write for Bulletin 359

Here's what Morse's entry into the "Timing"® Belt field means to you . . .

Nobody gives you a more impartial analysis of your power transmission problems than Morse, because . . . *only Morse* offers all four of these basic drives plus a complete line of power transmission products

Basic Drives: Roller Chain, Silent Chain, Hy-Vo® Drives, and "Timing"® Belt.

Chain: High-Endurance (H-E), 8-series (Super Strength), Double-Pitch, Conveyor, Implement, and Attachment; AL, BL, Cable Chain, and Rollerless Lift Chain; Industrial Standard and 3/16″ Silent Chain.

Stock Sprockets: Plain Bore, Finished Bore, Taper-Lock—also made to order.

"Timing" Belt Sprockets: Plain Bore, Taper-Lock, Q.D.—also made to order.

Couplings: Flexible Roller Chain Couplings, Flexible Silent Chain Couplings, Morflex Couplings, Morflex Radial Couplings, and Marine Couplings.

Driveshafts: Morflex and Radial Driveshafts.

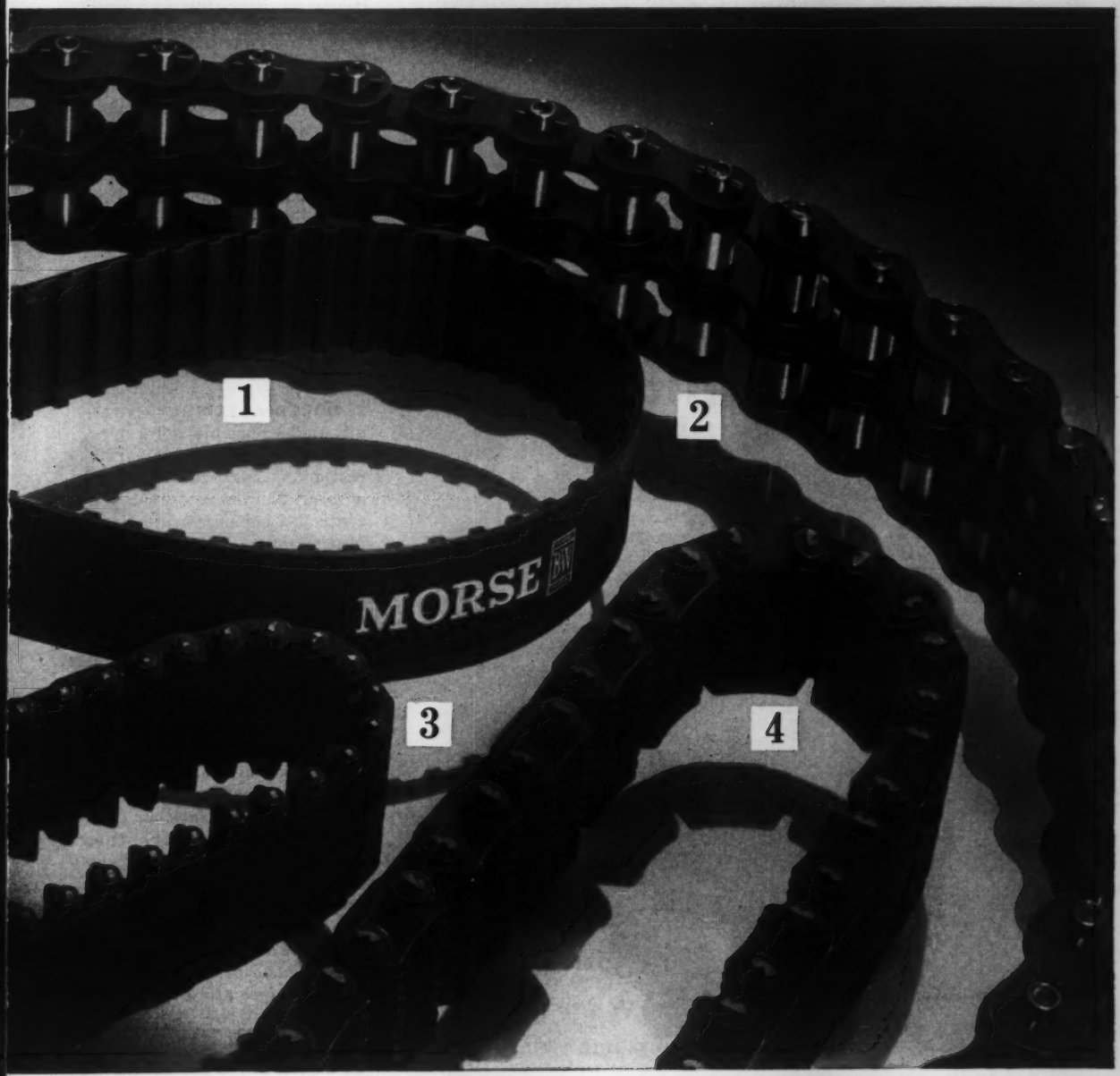
Clutches: Cam (Over-Running, Back-Stopping, Indexing); Pullmore; Over-Center, Centrifugal.

Speed Reducers: Eberhardt-Denver "RW" poweR-gear® Reducers; Gear Motors; "L" Worm Gear Reducers; "VX" and "DVX" Conveyor Drives; Miter Boxes; Helical Reducers.

Torque Limiters.

Look for your local Morse distributor in the Yellow Pages under "Power Transmission," or write:

MORSE CHAIN COMPANY, Dept. 6-99, ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario



1. "Timing" Belt . . . for light weight and lubrication-free operation. Morse "Timing" Belts give positive, high-efficiency transmission from 0 to 16,000 FPM, 1/100 HP to 1,000 HP . . . provide slip- and stretch-proof service for life of drive.

2. Roller Chain . . . for low and medium speed applications. Precision-finished Morse Roller Chain is specially treated to withstand shock and fatigue, assure less maintenance, longer service life. Patented Spirol Pin Fastener construction.

3. Silent Chain . . . for smoother, quieter operation at higher speeds. In Morse Silent Chain the patented rocker joint operates with less friction and wear. It provides a cooler-running chain drive, with higher efficiency and longer service life.

4. Hy-Vo Drive . . . for extremely high speeds and horsepower. Exclusive with Morse, extra-tough Hy-Vo Drives transmit mile-a-minute speeds, and up to 5,000 hp loads; require minimum shaft space, usually eliminate outboard bearings.

REMEMBER: The toughest jobs in power transmission come to Morse, because *only Morse* offers one-source service on all four of these basic components . . . and backs them up with technical know-how based on over 60 years' experience solving power transmission problems.

MORSE MORSE B-W * A BORG-WARNER INDUSTRY

*Trademark

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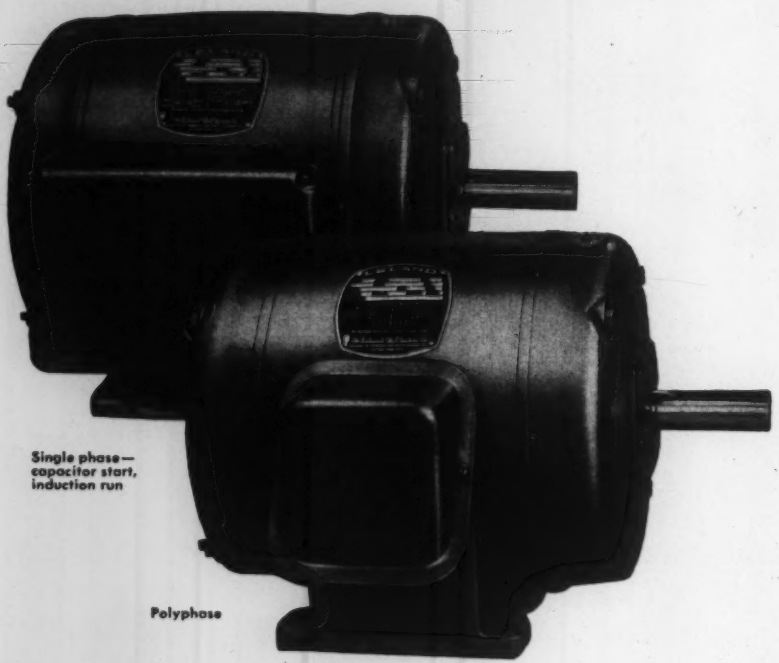
From the shaft out through the Leland nameplate...



Single phase—capacitor start, induction run

Polyphase

1. FULL-STRENGTH PROTECTIVE EXTERIOR—one-piece cast iron center frame with double-supported base mounting pads—super-rigid throughout. Cast iron end-frames carefully machined provide absolute bearing support and alignment, and establish uniform air-gap.

2. BEARINGS—Oversize, double-shielded, with high radial and thrust capacity—pre-lubricated.

3. ROTOR ASSEMBLY—virtually indestructible, solid pressure cast aluminum, integrally cast double fans, shafts ground *all over*. Skewed rotor slots and controlled balance for quiet, vibrationless power.

4. STATOR ASSEMBLY—a *superior electrical and mechanical* construction. Pressure stacked core of uniformly punched and *scientifically annealed* laminations gives *superior magnetic characteristics. Cuffed, laminated mylar slot insulators, plus slot feeder insulator*, protects insertion of *heavy formvar insulated copper windings*, then secured with waxed maple pegs. *Inter-phase protective insulation* and sleeved lead stubs are all double linen cord laced; finally the entire assembly is *pre-heated and double dipped and baked in synthetic insulating varnish.*

5. CONDUIT BOXES—Large capacity, diagonally split box makes easy connections a cinch on polyphase motors. Single phase units further provide a convenient terminal board plus ready access to capacitors or thermal—all in an ample cast iron box. Either type mounts up, down, right, or left.

For more information, contact our representatives in all principal cities, or write or wire us direct.

. . . integral horsepower motors by Leland offer proven quality. Created and built with the same design flexibility, quality materials, and inflexibly rigid quality control that keep Leland the *world's leader* in motors for the petroleum industry, where Leland Underwriters' Listed fractionals and integrals outsell all others combined. Here are several of many reasons why specifying Leland integrals for almost any use means specifying *lifetime satisfaction.*

AMF

THE LELAND ELECTRIC COMPANY
Dayton 1, Ohio
Division of American Machine & Foundry Company

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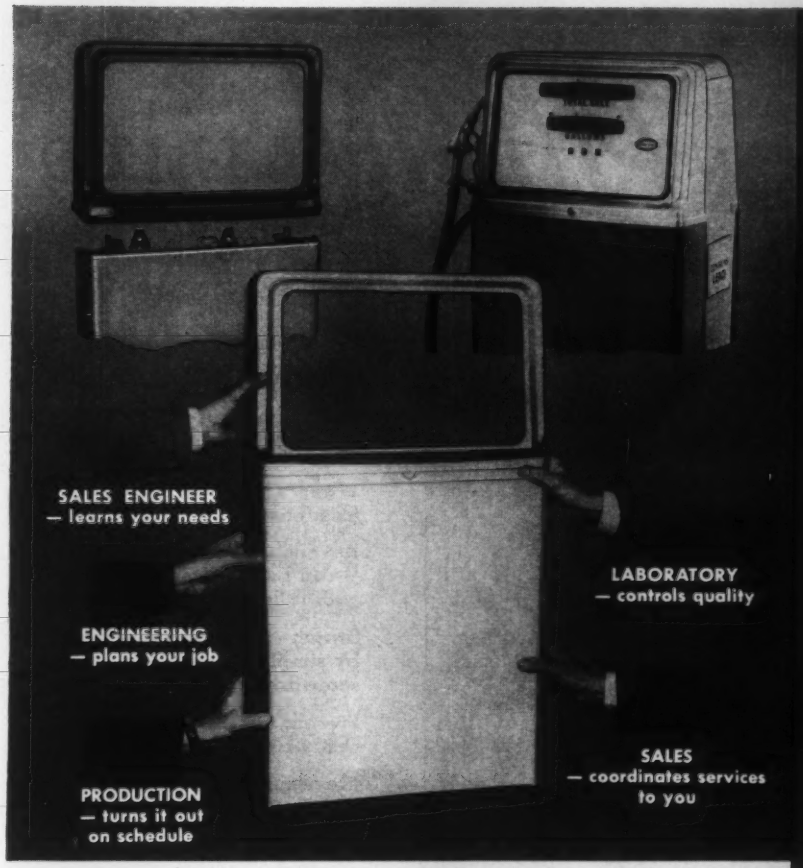


MANY HANDS MAKE *BETTER* WORK

Every inquiry, every order you send to T & W receives special attention from *each* of a battery of experts. The ideas, the supervision, the driving force of *each* one contribute, for the best results. Teamwork is an important part of T & W Technique — a way of producing forgings and stampings for you so they usually cost you less at your point of assembly.

SALES OFFICES NEW YORK • PHILADELPHIA • STAMFORD
CHICAGO • INDIANAPOLIS • DETROIT
HOUSTON • LOS ANGELES

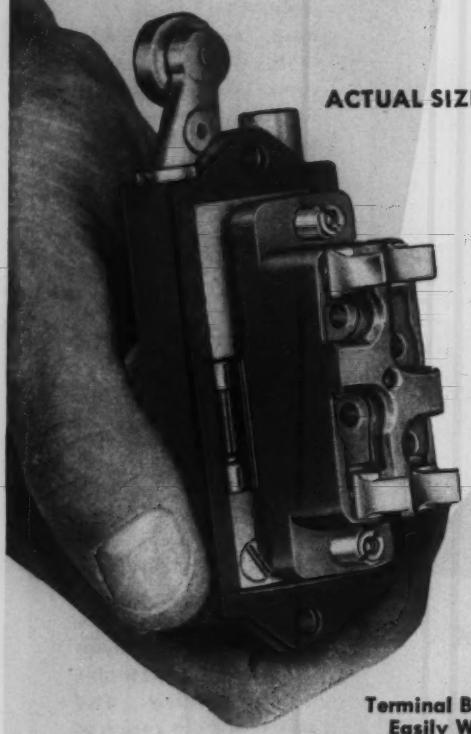
FORGINGS & DEEP DRAWN STAMPINGS

TRANSUE & WILLIAMS
ALLIANCE, OHIO, U.S.A.

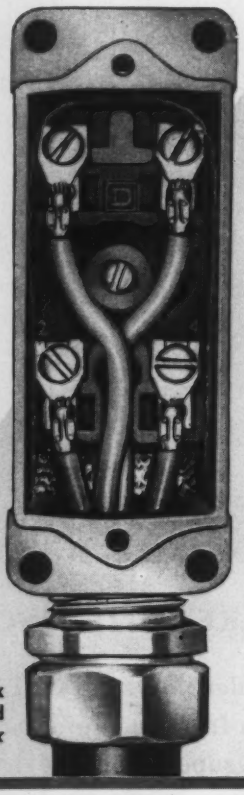
Name_____ Title_____
Company_____
Street_____
City_____ State_____

This New *PLUG-IN* LIMIT

CLASS 9007, TYPE AW



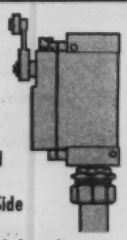
ACTUAL SIZE



Terminal Block Easily Wired ***Without Removing from Box***

- Oil-tight construction
- Switch plugs in—in seconds
- Mounts without disassembly
- Wired without removing from box
- Reversible plug-in unit —can be plugged-in with roller arm at either end
- Switch action can be reversed by simple screwdriver adjustment
- Present installations easily converted to plug-in
- Precision switch mechanism —only 5° to operate— 25° overtravel in either direction
- Graduated markings around hub of roller arm simplify accurate settings
- Same price as standard Square D oil-tight limit switch

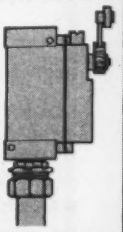
6 MOUNTING ARRANGEMENTS...WITH 1 DEVICE!



Switch Mounted on its Left Side

Switch Mounted on its Base with Conduit at Bottom

Switch Mounted on its Base with Conduit at Top



Switch Mounted on its Right Side

In any of the above arrangements, conduit can enter at either top or bottom by reversing box position

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

SWITCH is SO EASY to Use!

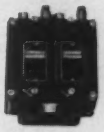
SQUARE D LIMIT SWITCHES ARE Designed TO DO HUNDREDS OF JOBS – BETTER!

SMALL OIL-TIGHT LIMIT SWITCH -- CLASS 9007, TYPE AW

Surface mounting, roller arm operated

Flush mounting, push rod operated

Surface mounting, push rod operated

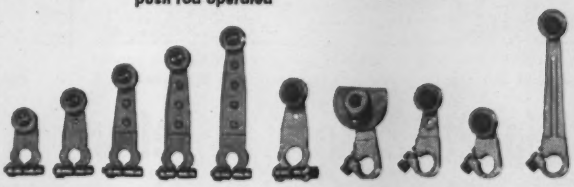


Duplex switch, surface mounting, push rod operated

Duplex switch, flush mounting, lever arm operated

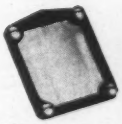
Flush mounting, lever operated

ROLLER ARMS AVAILABLE IN WIDE RANGE OF DESIGNS AND LENGTHS...



HEAVY-DUTY OIL-TIGHT LIMIT SWITCH -- CLASS 9007, TYPE T

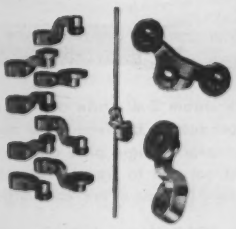
Continuously adjustable lever arms, up to 80° overtravel



Transparent plastic cover available for instant inspection

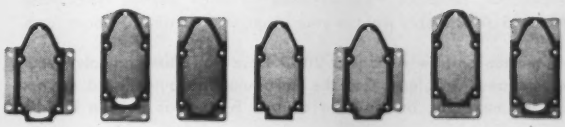
Eleven contact arrangements in one switch; only a screwdriver is required

Rear shaft design for inaccessible locations



Many sizes and types of operating arms

WIDE VARIETY OF BASE PLATES AND MOUNTING HOLES...



Write for BULLETIN 9007 AW to Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

Worker holds 2802 Hose Line of Teflon in curing mold. When tire carcass is inserted, hose line supplies steam pressure to inflate it against mold.

Aeroquip 2802 Hose of Teflon Solves Steam Line Problem

Major Tire Manufacturer Eliminates Constant Maintenance On Steam Curing Mold

A flexible steam line made of Aeroquip 2802 Hose of Teflon promises to solve a production bottleneck for one tire producer. Used on steam curing molds, it replaced rigid pipe and swivel joints that were a constant replacement problem due to steam leakage. Service life of 2802 Hose of Teflon is practically limitless in this application.

Aeroquip 2802 Hose of Teflon gives unequalled performance wherever extreme fluid temperatures are encountered (up to 500°F.) or where chemical stability, lubricity, flexing and long service life of the hose are critical factors. Use of detachable, reusable "*super gem*" Fittings permits quick hose line assembly and disassembly right in your plant, using ordinary bench tools.

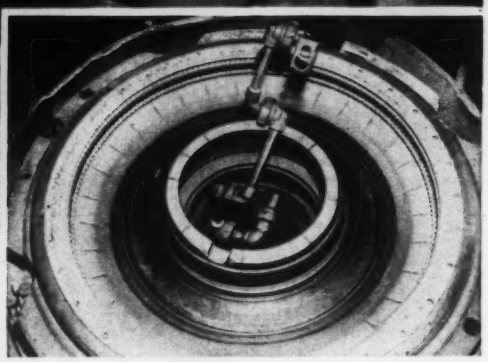
Get full information on how Aeroquip 2802 Hose of Teflon can solve your fluid line maintenance problems. Call the Aeroquip Distributor listed in your Yellow Page Phone Book, or mail the coupon below for Bulletin IEB-40.

Aeroquip
REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD



Before: Pipe and swivel joints formerly used required constant maintenance due to leakage at swivel joints.

After: Aeroquip 2802 Hose of Teflon withstands constant flexing under high steam temperature without leaking.

"*super gem*" is an Aeroquip Trademark.
Teflon is DuPont's tradename for its tetrafluoroethylene resin.
*U.S. Patent Nos. 2,833,567 and 2,731,279.

MD-9

AEROQUIP CORPORATION, JACKSON, MICHIGAN

Please send me a copy of Bulletin IEB-40 on Aeroquip 2802 Hose of Teflon.

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

Circle 462 on Page 19

Circle 463 on Page 19→

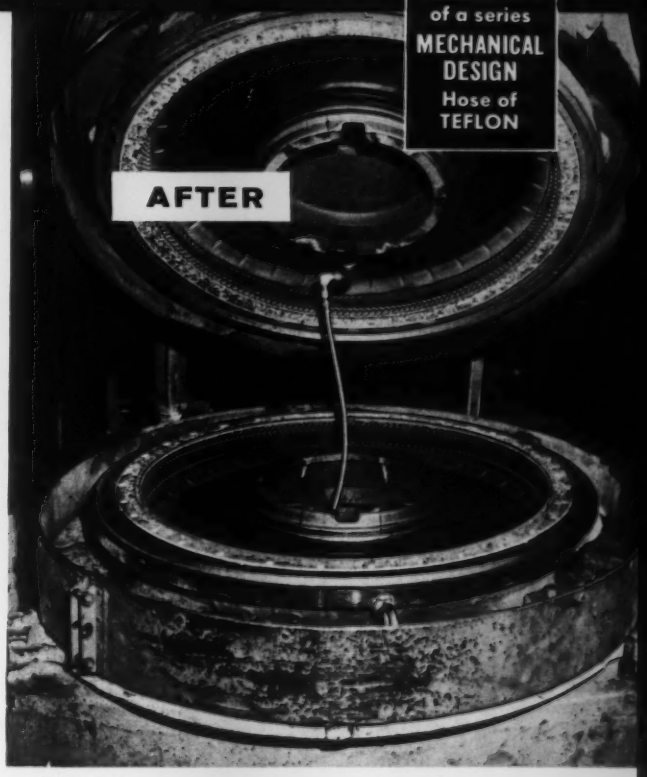
DUPONT

ENGINEERING FACTS ABOUT

TEFLON®

FLUOROCARBON RESINS

Number M-3 of a series MECHANICAL DESIGN Hose of TEFLON



Pipe and swivel joint installations supplied steam heat and pressure to bag liners (not shown) for tire curing presses. Steam leakage and frequent maintenance were constant problems.

Replacement with hoses of TEFLON, as above, reduced steam leakage, resulting in lower maintenance costs. These less cumbersome connections also provide heat resistance, flex life, and reduced corrosion.

Unmatched stamina of hose lined with TFE resins brings production costs down

FOR maximum performance and durability plus reduced maintenance costs, hose liners of TEFLON TFE fluorocarbon resins offer this valuable combination of benefits:

Highly resistant to heat, TFE resins are rated for continuous service up to 500°F and withstand live steam and superheated water.

Hose of a TFE resin is exceptionally durable under continuous flexing, torque stress, vibration, and impulsing. This has been proven by strenuous military qualification tests and numerous industrial uses. With reinforcing, service pressures up to 6000 psi are being achieved.

TFE resins are completely inert to virtually all chemicals. This includes reagents such as nitric and hydrofluoric acids, and solvents including the non-flammable hydraulic fluids.

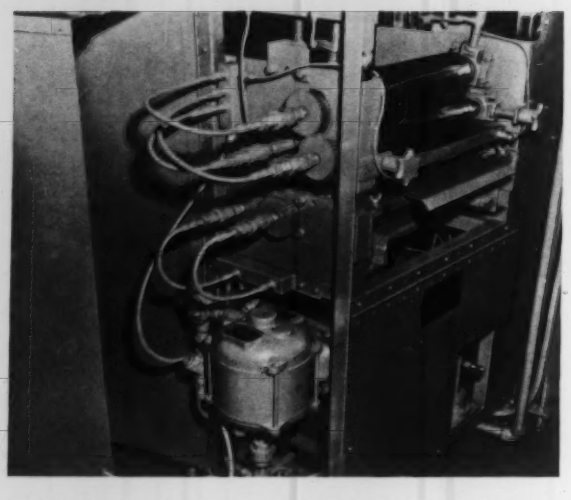
Liners of TFE resins provide a "waxy" inner surface which repels adhesion of sticky substances and scale, and are therefore readily cleaned and sterilized.

Today, using these valuable properties, a wide selection of industrial hose constructions with liners of TEFLON are available to meet your particular needs. In addition to the wire braided reinforcement and a variety of industrial couplings, there are elastomer coverings, fiber braids, air-duct styles, and convoluted liners of TEFLON offering greater flexibility.

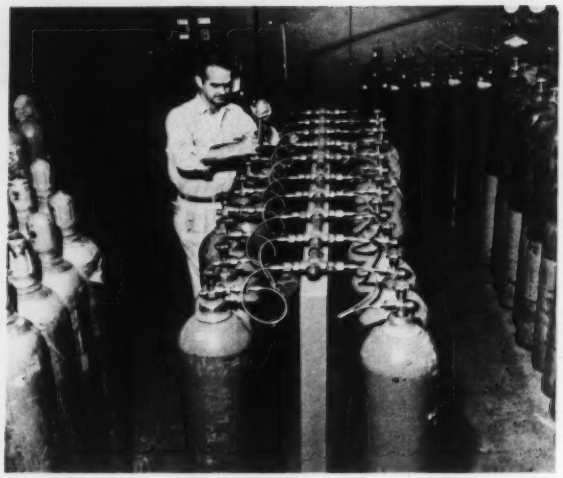
Examples of the cost cutting advantages made possible by hose of TFE resins are included on this and the following page. They may suggest ways that your machinery can profit from the remarkable properties of hose lined with TEFLON.

OVER

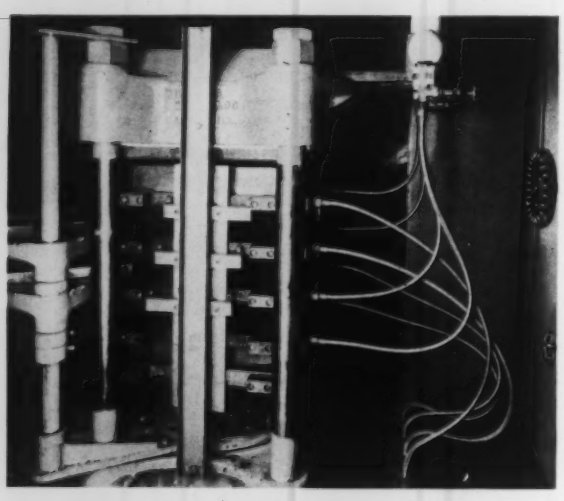
Hose of TFE resins takes live steam, corrosives, pressure, flexing without failure



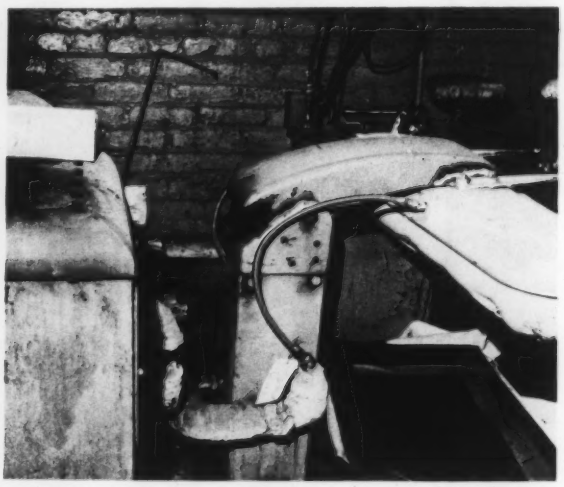
Hot Oil Service: Hose of TFE resin helped adapt this standard roller coater machine to high-temperature service. To suit customers' needs, the hose had to handle heat transfer oil at up to 400°F. Hose liner of TEFLON provided the necessary resistance to heat and solvents.



Cylinder Loading: At this plant, rubber hoses or metal pigtails lasted 3 months at best, loading helium, nitrous oxide, and carbon dioxide into cylinders. Hoses lined with TEFLON show no deterioration after 16 months. Reduced stiffening and frosting at the 0° F. loading temperature improved the weighing accuracy.



Reduced Scale Fouling: Hose is in alternate 350°F. steam and cold water service on this plastics platen press. Prior to the use of TEFLON, scale formation plugged hose in a matter of months. After 5 years, seven hoses lined with TFE resin were still unharmed and unplugged.



Longer Flex Life: Many cleaners and garment manufacturers are now using hose lined with TFE resins carrying steam to their presses. Above is one of 100 units at a location so equipped 16 months ago, and there have been no failures. Previously, hose life on some units was as low as two weeks.

FOR MORE INFORMATION...

about reliable hose installations, and the design properties of Du Pont TEFLON TFE-fluorocarbon resins that make possible this superior hose performance, consult your hose supplier or write to: **E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 25917, Du Pont Building, Wilmington 98, Delaware.**

In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

TEFLON *is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.*

TEFLON®

TFE-FLUOROCARBON RESINS

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

This is an actual photograph of 1½" Springfield "400" hose.

NOW!

design with large diameter Teflon* hose that bends like this!

6¾"

If you design fluid handling, transfer, or hydraulic equipment, you already know Teflon hose. Wonderful! Except, up to this time larger diameters were not really flexible. But *now* look!

SPRINGFIELD "400" WITH FINGER FLEXIBILITY ONLY TITEFLEX HAS IT!

- Minimum bend radius: *only 3⅓ times the hose diameter!* Thanks to the exclusive TITEFLEX process.
- Teflon innercore with all its properties. It's tough, lightweight, inert, resistant to corrosion and temperature extremes. Flex life is almost endless.
- Available now up to 2" in diameter, lengths to 25 feet (soon to 50!).
- Fittings prove failure-proof—right up to burst pressure of hose!
- In many cases, a shorter Springfield "400" hose can replace extruded hose at big savings.

Springfield "400" has already made exciting news in scores of applications—new uses crop up every day. How about your field? Our bulletin will set design ideas clicking. Ask your TITEFLEX distributor (see the Yellow Pages) for a copy. Or drop us a line direct.

titeflex

Do these Springfield "400" applications suggest anything to you?

TANK, CAR, BARGE, MILITARY VEHICLE application • CHEMICAL • HIGH TEMPERATURE AIR • PLASTIC COMPOUND • HOT TAR AND ASPHALT • LIVE STEAM • CORROSIVE FLUID • HIGH TEMPERATURE HYDRAULIC SYSTEMS • AIRCRAFT: high temperature fuel and lubricating systems • MISSILE: fuel and oxidizer lines of vehicles and ground support •

titeflex inc. springfield mass. PACIFIC DIVISION • SANTA MONICA • CALIFORNIA

*Teflon is a duPont trademark
**T.M. of Titeflex, Inc., Pat. Pending

#5 HONEYCOMB AS AN ENERGY ABSORBER

While honeycomb materials are used principally in light-weight, high-strength sandwich structures, increasing emphasis has been placed on the use of honeycomb to control forces exerted on decelerating objects. Such control is highly desirable in cushioning the impact of air-dropped supplies, protecting instrumented missile assemblies, providing impact-limiting linkages in landing gear structures, packaging fragile items, and protecting human occupants of high speed vehicles.

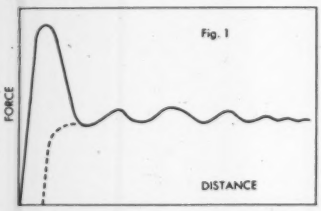
The Problem

Instances requiring impact energy absorption are generally typified by low tolerable deceleration rates for the structure or its contents, high impact velocities, and small maximum allowable stopping distances. Such absorbers as mechanical springs, sponge or solid rubber, foams, cork, and wadding generally exhibit spring characteristics, in that the force transmitted through these absorbers to the object being stopped increases continuously through the distance in which the absorbers contract. In addition, many of these materials do not absorb energy, but merely store it for release as rebound energy.

If an absorber could exert a relatively constant non-rebound force throughout the entire stopping distance, that distance could be shortened, or alternately, the maximum force acting on the object in the same stopping distance could be materially reduced.

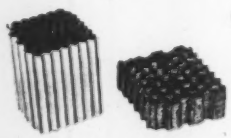
Advantages of Honeycomb

Honeycomb core materials tend to follow such a constant force curve, as shown in Figure 1.



The initial peak on the curve represents the point at which compressive failure begins. This peak can be lowered by prestressing the core to produce slight initial compressive failure. When subjected to further or subsequent loading, the prestressed core proceeds immediately to carry the crushing load, as shown by the dashed line curve in Figure 1.

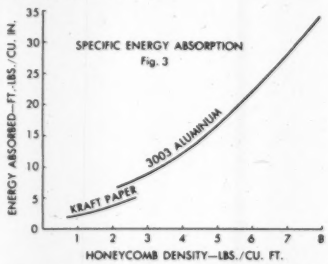
Figure 2 illustrates the appearance of aluminum honeycomb core before and after compressive failure.



By designing a honeycomb core assembly with a specified cell depth this constant force can be applied over a predetermined stopping distance.

Available Materials

These principles apply to aluminum and paper honeycomb, and most similar honeycomb core materials fabricated from ductile metals and fabrics. Figure 3 indicates the general range of energy absorption capacity available in aluminum and paper materials.



These capacities can be further increased by filling the cells with various foamed materials.

Optimum Solution

The choice of materials by the designer will depend upon the particular requirements of the application. But it seems apparent that the utilization of honeycomb offers the optimum solution—in terms of weight and volumetric efficiency—to many types of energy absorption problems.

Others in This Series. Copies sent on request

1. **Honeycomb Sandwich Panels**
2. **Honeycomb Sandwich Materials**
3. **Successful Honeycomb Sandwich Design**
4. **Honeycomb Design Characteristics**

INFORMATION REQUEST

Send to Hexcel Products Inc. Dept. 57
2332 Fourth Street, Berkeley 10, California.

NAME_____

TITLE_____

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CITY_____ ZONE____ STATE_____

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World leader in honeycomb

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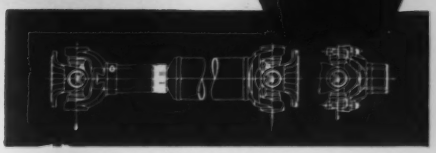
Plants: Oakland and Berkeley, Calif.; Havre de Grace, Md.
Sales Offices: Long Island City, N.Y.; Fort Worth, Texas; Inglewood, Calif.

Circle 465 on Page 19

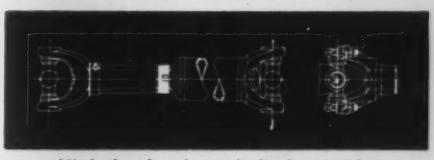
NEW SPICER 1550 SERIES UNIVERSAL JOINTS...



Standard Assembly
Flange Yokes or End Yokes are Optional

A bigger, more rugged universal joint for trucks with 29,000-30,000 GVW

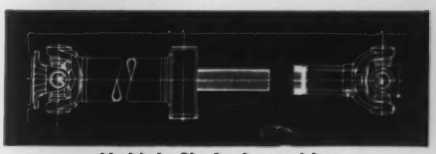
Spicer is now manufacturing a completely new series of universal joint . . . the 1550 series. With 20% greater bearing factor and a minimum elastic limit 20% greater than previous 1500 series joints, the 1550 series is a bigger performance value . . . *at lower cost.*



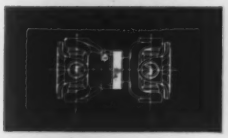
High Angle—Inter Axle Assembly
End Yokes are Standard

The new 1550 series universal joints give you **these important performance advantages:**

- Reverse Spline Center Bearing construction.
- Crowned Bearing Races, for better bearing alignment, longer life.
- "U" bolt and snap ring design for reduced maintenance costs.
- Synthetic double lip type seal, for tighter, more positive sealing.
- Shorter length flange face to flange face on short coupled sets, to take full advantage of available space.
- Extremely close limits of static and dynamic balance for vibration-free operation.



Multiple Shaft Assembly With Center Bearing



Short Coupled Assembly
Flange Yokes or End Yokes are Optional

The 1550 series is now available in all present variations of the 1500 series—including short coupled, high angle and long slip propeller shafts.

For more complete details on the new 1550 series universal joints write to Dana Corporation, Toledo 1, Ohio.

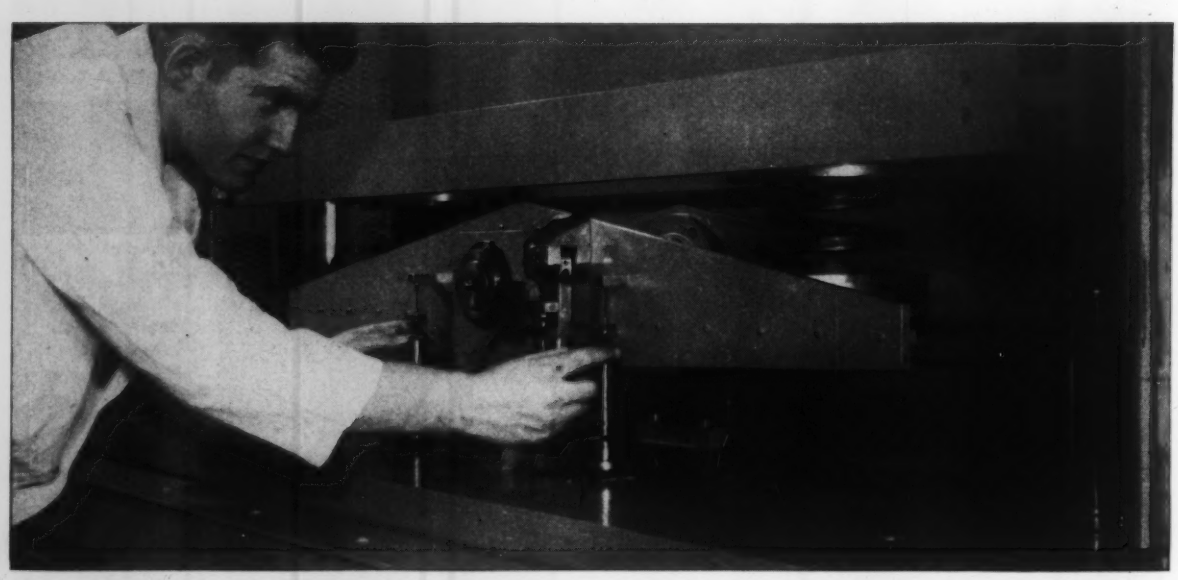
DANA Spicer

DANA CORPORATION
Toledo 1, Ohio

SERVING TRANSPORTATION—Transmissions • Auxiliaries • Universal Joints • Clutches • Propeller Shafts • Power Take-Offs • Torque Converters • Axles • Powr-Lok Differentials • Gear Boxes • Forgings • Stampings • Frames • Railway Drives.

Many of these products are manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario

USS American Springs give longer life,



In the AS&W Spring Laboratory a semi-resonant spring fatigue machine is testing the Lipe-Rollway clutch spring. At speeds of 700 cpm this spring is functioned beyond its normal life span and at higher than normal stresses to prove conclusively its superior design as a clutch spring.

A USS American flat wire compression spring is shown in place in the Lipe-Rollway clutch. Four round wire compression springs are also being installed in the clutch.

better performance in heavy-duty clutches

..thanks to AS&W Spring Engineering Research Service

The Lipe-Rollway Clutch Division, Lipe-Rollway Corporation, Syracuse, N. Y., manufactures automotive clutches for heavy-duty trucks, tractors, buses and other large mobile equipment. Because USS American Springs play a vital part in the performance of these clutches, Lipe-Rollway asked the AS&W Spring Engineering Research Service to test the springs and determine if any changes should be made in the design to improve and maintain the high performance standards.

As a result of these tests the AS&W Engineers recommended certain important changes to give the springs longer life. After this recommendation was adopted by Lipe-Rollway, Mr. Harvey Gray, Chief Inspector & Quality Control, had this to say: "Exceptional service has been realized from our American Steel & Wire Springs."

If you have a spring problem or would like advice on the use of springs in your product, get in touch with our general office in Cleveland, or any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steels—from steel chemistry through product application—to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal.

American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.

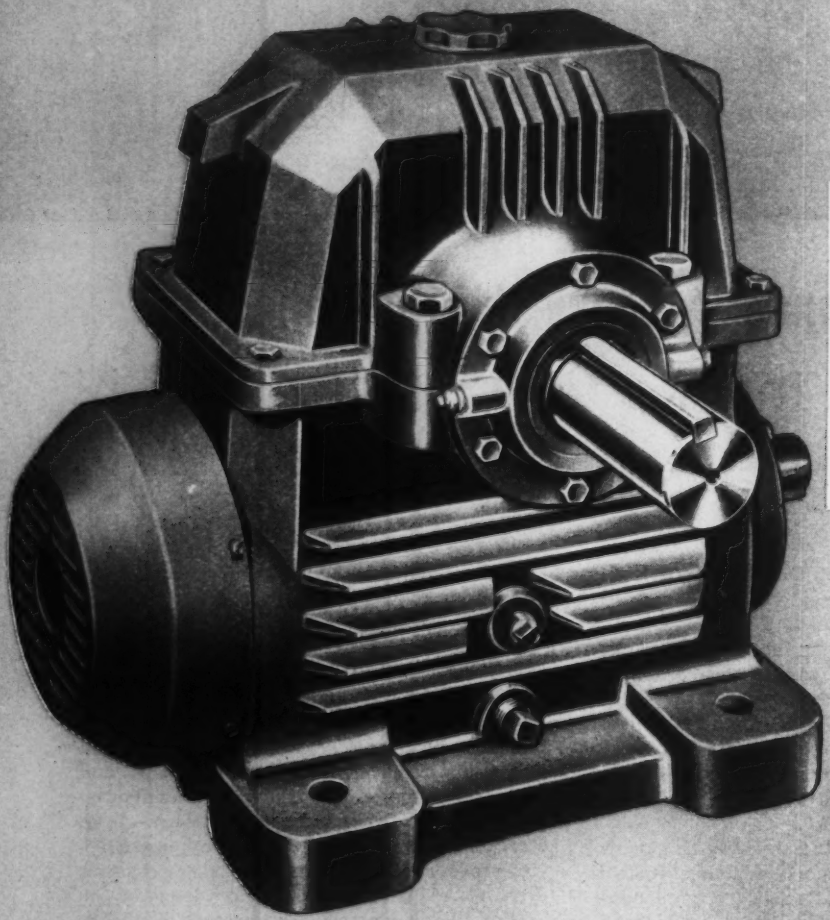
USS and American are registered trademarks

American Steel & Wire Division of USS **United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

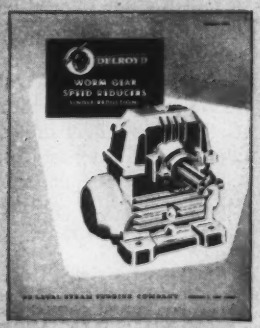
DELROYD
SPEED REDUCERS

De Laval Announces All New Line of Single Reduction Speed Reducers



DELROYD
TYPE B
fan cooled 5" through 12" center distance
★

Send for this new 32-page Bulletin 3805 today.



New Delroyd single reduction speed reducers are available in a wide range of sizes and horsepower ratings. These worm gear units include centrifugally cast gears and fan cooling, and carry *the new AGMA ratings.*

DE LAVAL *Steam Turbine Company*

858 NOTTINGHAM WAY, TRENTON 2, N. J.

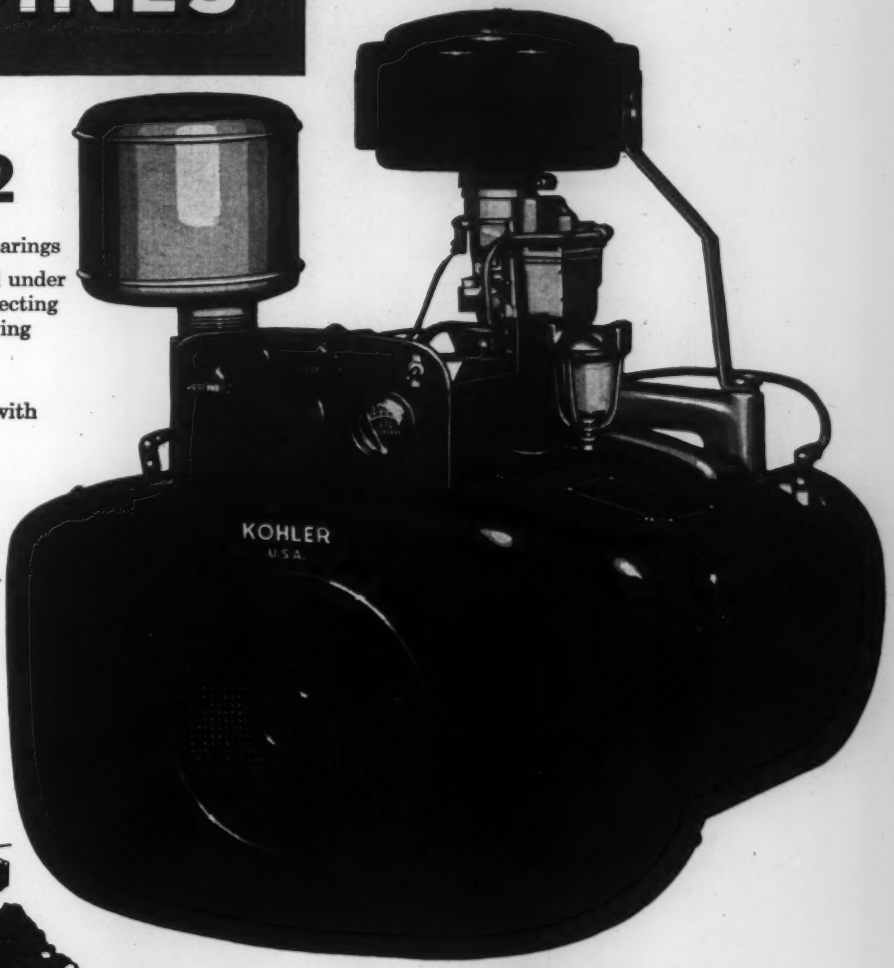
DL 479

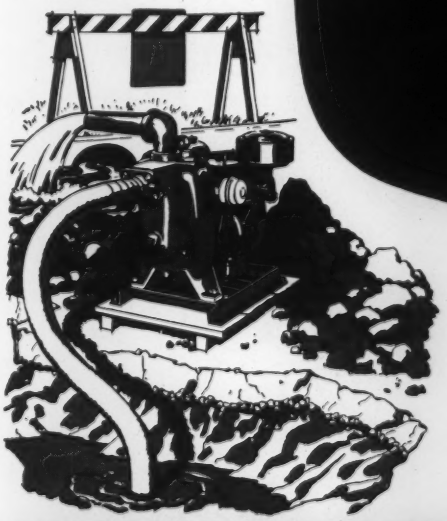
KOHLER ENGINES

4-cycle Short-stroke Air-cooled

MODEL
K662

- Tapered roller main bearings
- Gear pump supplies oil under pressure direct to connecting rod bearing, other moving parts
- Rugged automotive diaphragm fuel pump with manual primer
- Stellite exhaust valves and seats with positive rotator
- Cylinder and crankcase are made from metallurgically controlled close grained cylinder iron
- Mechanical governor for accurate R.P.M. control





Kohler engines are conservatively rated, quick-starting, reliable.

Experienced application engineers will help you choose a Kohler engine for your job.

Kohler Co. has manufactured internal combustion engines for 38 years.

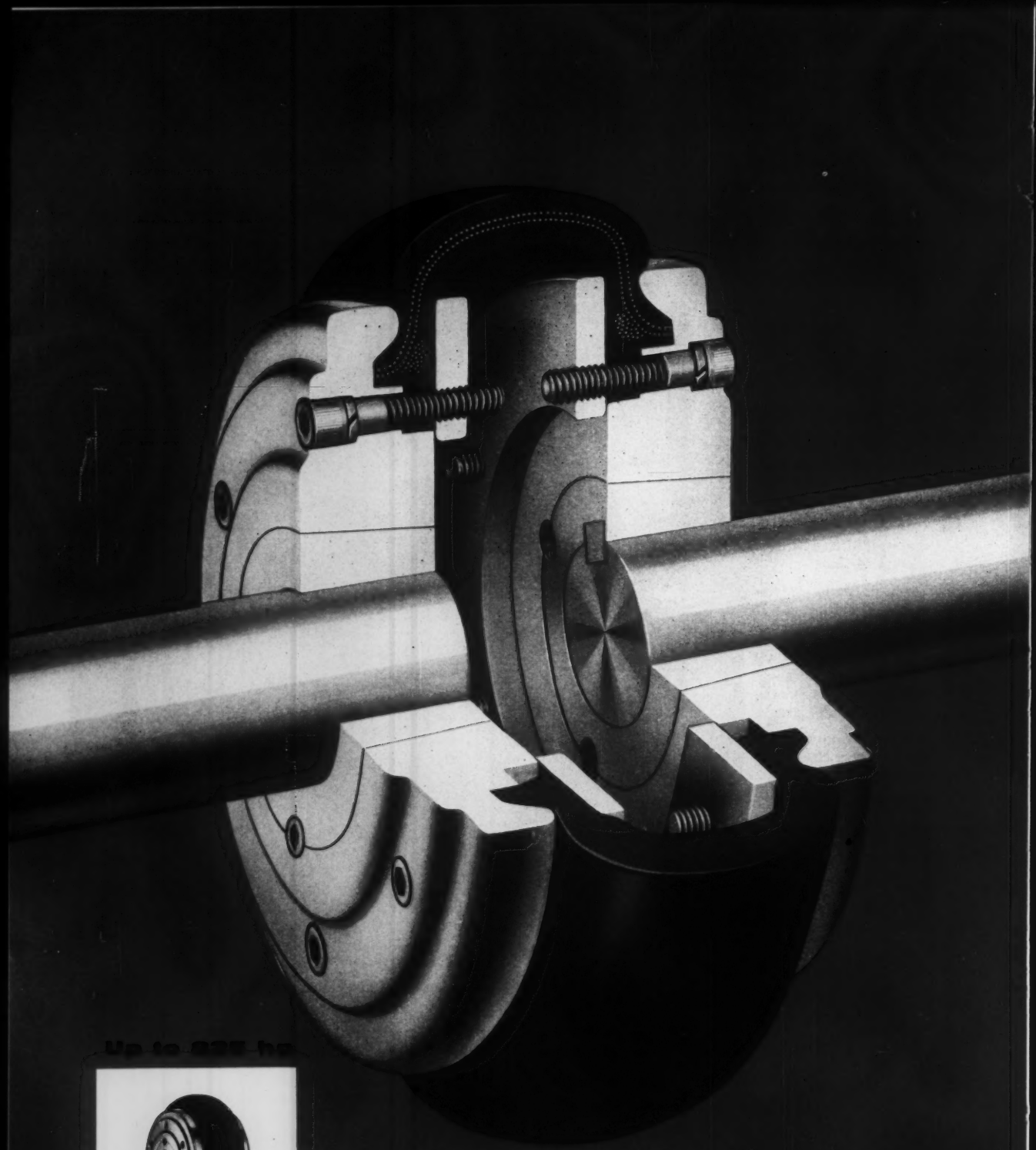
Send for illustrated booklet.

FROM 3 TO 24 H.P.

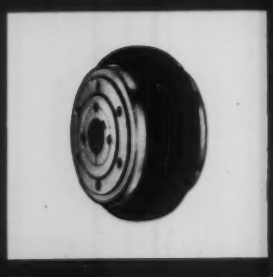
KOHLER CO. Established 1873 KOHLER, WIS.

KOHLER OF KOHLER

Enameled Iron and Vitreous China Plumbing Fixtures • Brass Fittings • Electric Plants • Air-cooled Engines • Precision Controls



Up to 825 hp

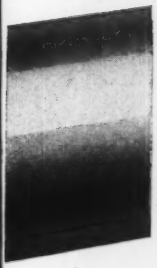


NOW! THE COUPLING WITH THE 4-WAY FLEX!

DODGE Para•flex

FLEXIBLE CUSHION COUPLING

THE NEW IDEA IN FLEXIBLE COUPLINGS... WITH A FLEXING BODY THAT AUTOMATICALLY COMPENSATES FOR ALL COMBINATIONS OF MISALIGNMENT AND END FLOAT... AND CUSHIONS SHOCK LOADS!



THIS Coupling "swallows up" misalignment! Its ability to handle multiple displacement is exceeded only in a universal joint. It outperforms the most complex coupling mechanisms—yet it operates with the simplicity—*and the dependability*—of a modern tire!

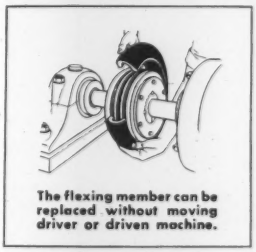
The technological advances that contribute to the miracle of today's truck tires, which are engineered to carry tremendous loads at high speeds and stand terrific shock, have made this new type of coupling possible.

The heart of Para-flex is a tire with synthetic tension members bonded together in rubber. It is pliant. It "fits itself" to changing shaft conditions—angular, parallel, end-float, *or any combination of all three!* Depending upon the size of coupling and duration of shaft misplacement, it handles angular misalignment up to 4°, parallel up to ⅛" and end-float up to 5/16".

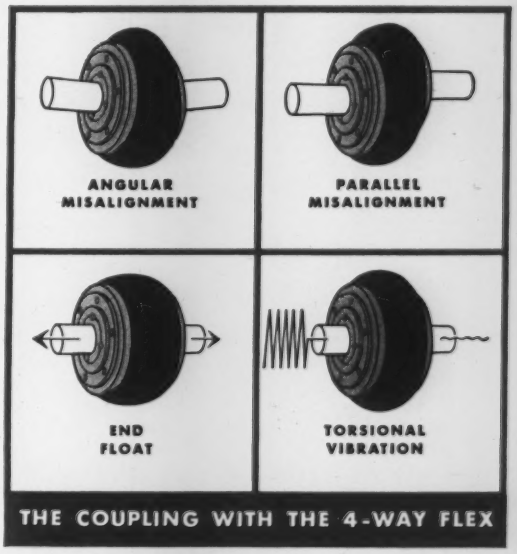
It cushions the stresses of shock loads to a remarkable degree. And it tends to absorb torsional vibration—reducing noise and protecting machinery from vibration's destructive forces.

There is no metal-to-metal contact between shafts. They are insulated. No lubrication is required.

Para-flex takes a minimum of space on the shaft. Mounting is simplified through the use of standard Taper-Lock bushings—no reboring, no machining. Safety is promoted by flush design; there are no protruding parts. And since the flexible member is molded with a transverse split, it can be replaced *without moving either the driver or driven machine!*



The flexing member can be replaced without moving driver or driven machine.



THE COUPLING WITH THE 4-WAY FLEX

Para-flex Couplings are stocked by Dodge Distributors in popular transmission sizes. They are available from factory stock in capacities up to 825 hp at 1200 rpm. Call your distributor for early delivery to *make your own test.* You'll witness something revolutionary!

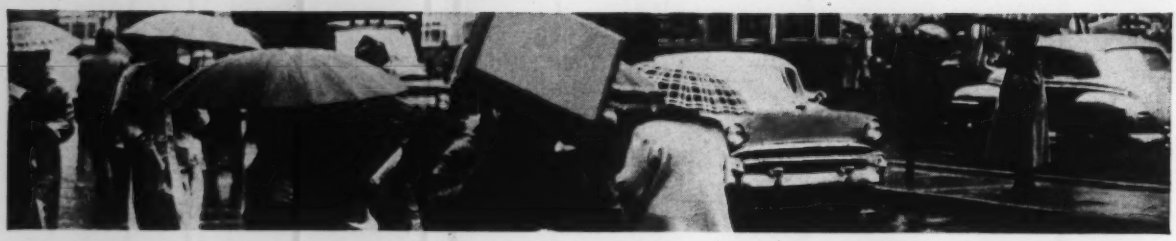
DODGE MANUFACTURING CORPORATION, 3300 Union Street, Mishawaka, Indiana

DODGE

of Mishawaka, Ind.

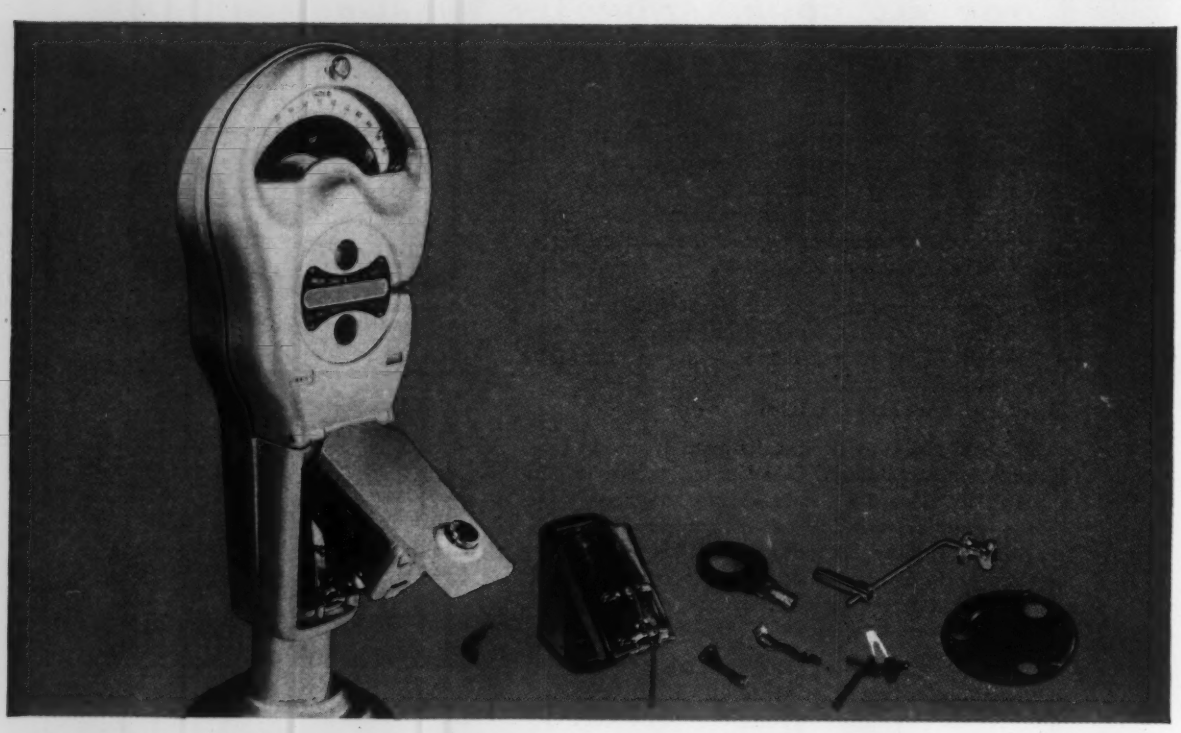
CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods in the mechanical transmission of power. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer." Or write us.

Circle 469 on Page 19



for strength, corrosion resistance and long-range dependability

. . . it had to be stainless



Of all modern mechanical marvels, only the automobile itself takes more abuse than the parking meter. The meter is not only cussed in conversation, but it is kicked, crashed, bent, rained on, robbed, and stuffed with junk by small boys. Critical parts like timing devices, dumping coin receivers, gear rotating teeth, etc., have been made from Carpenter Stainless for over 15 years by this manufacturer. Carpenter has a Stainless Steel that can give you this same dependability on your important parts. Call in your local Carpenter Representative to look over the requirements for your toughest job. The Carpenter Steel Company, Reading, Pa.

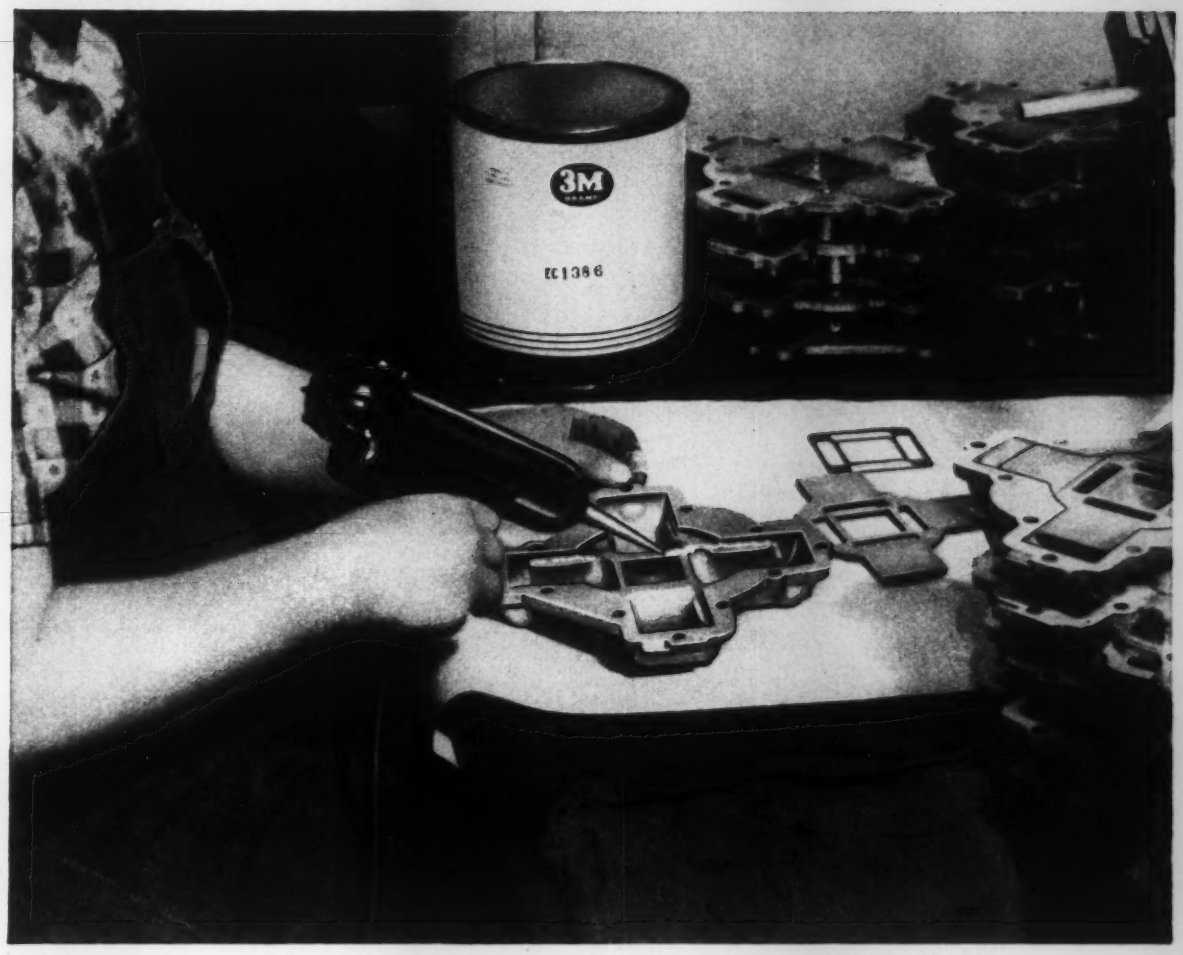
a new company 70 years old

Carpenter steel

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 470 on Page 19

NOW! FABRICATE COMPLEX CASTINGS WITH 3M ADHESIVES!



Here's a new, virtually fool-proof way to fabricate complicated hollow castings. Simply bond and unitize individual *die*-cast *sections* with high-strength 3M structural adhesives, such as EC-1386. You'll cut rejects and costs, boost production, too.

Die-casting of sections eliminates rejections due to blow holes in sand core castings . . . means smoother, more detailed parts because of the machined surface of the metal die. And by bonding with 3M Adhesives rather than mechanically fastening sections, there's no need for costly machining and equipment, no wasteful bosses or flanges to eat up space. Easily applied with a flow gun, EC-1386 is 100% nonvolatile, and requires no pre-drying before joining sections.

With EC-1386, indexing or pressure jigs are not needed. The adhesive cures to high ultimate strength quickly in an air-circulating oven. (At 500°F, curing time is only one to two minutes.) And the cured bond can be machined for final touch-up operations.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

3M structural adhesives are doing many things in many fields. For more information and literature on the complete line, contact your 3M Field Engineer or write direct: A. C. & S. Division, 3M, Dept. SAR-109, St. Paul 6, Minnesota.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

New Century Electric motor starts on 50% less current

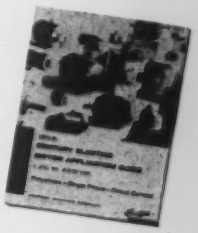
Here is the answer to power company limits on starting current for *single phase* motors . . . a new Century Electric capacitor-start motor with a really low starting current. In the 20 hp size the *starting* current is 220 amps . . . as low as that for a normal 10 hp motor.

Applications — This capacitor-start, capacitor-run motor provides dependable starting and operating power for crop dryers, large irrigation pumps, hay dryers and machines started on an open clutch. Because of the high cost of running three phase power to isolated areas, most utilities prefer to supply single phase power . . . and this new motor means that users can have sufficient single phase horsepower for this type of equipment.

Specifications — You can get this new Century Electric motor in 7½ to 20 hp sizes. It is available in 1200 and 1800 rpm speeds at 230 volts. Totally-enclosed, drip-proof and explosion-proof enclosures are also available. Mounting dimensions are shown on the chart below.

Design features — Wire insulation on the new Century Electric CPF motor is vinyl acetal resin . . . slot cell insulation is bonded "Mylar" . . . combination gives tough mechanical protection, high dielectric strength and resistance to moisture. Motor is smooth and quiet running because of rigid cast iron frame. Rotor lamination is skewed for smooth start and quiet operation. High pressure aluminum casting gives rotor winding bars high density. Capacitor box comes in separate weather-protected enclosure . . . means it can be mounted conveniently next to control device or wherever space can be best utilized.

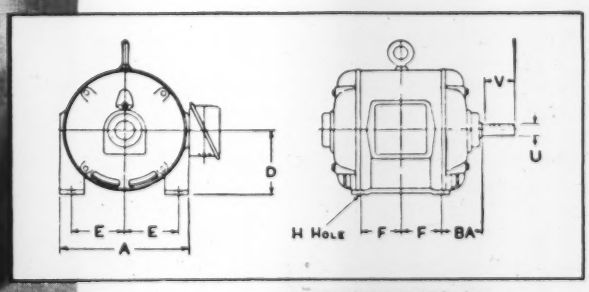
For more information on this new capacitor motor contact your nearest Century Electric Sales Office or Authorized Distributor. For detailed information on motor applications write for the new Century Electric Motor Application Guide . . . bulletin 270A.



CENTURY ELECTRIC COMPANY

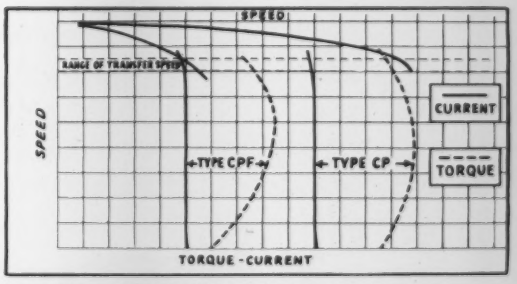
St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Century 59-11



MOUNTING DIMENSIONS
for new Century Electric capacitor-start motor.

Frame Size	Key	A	BA	D	E	F	H	U	V
256U	5/16 x 5/16	12½	4¼	6¼	5	5	11/32	1⅜	3½
284U 286U	⅜ x ⅜	14	4¾	7	5½	4¾ 5½	11/32	1⅜	4⅜
324U	½ x ½	16	5¼	8	6¼	5¼	21/32	1⅛	5⅜



TYPICAL SPEED-TORQUE curves for Century Electric Type CPF motor, compared with standard Type CP unit of similar capacity.

Circle 472 on Page 19

Short course in designing products that win sales honors

You're looking at a brand-new booklet that can mean longer service life, greater dependability, new applications, and new markets for your products. It gives the facts on the unusual properties of Roth Silicone Rubber . . . tells how Roth Silicone can stand up under an extreme range of temperatures, retain its conformity under compression, shrug off solvents, and resist weather, oil, and high-voltage corona. There's more, too . . . much more. Here's the full story on Roth Silicone Rubber Sheeting, both sponge and solid, and Roth Molded Silicone Rubber Parts . . . helpful details on their physical properties . . . down-to-earth reasons why Roth Silicones can cut production costs, simplify product design, and enable you to sell markets you couldn't touch before. Write for your copy of "Fire or Ice" today.

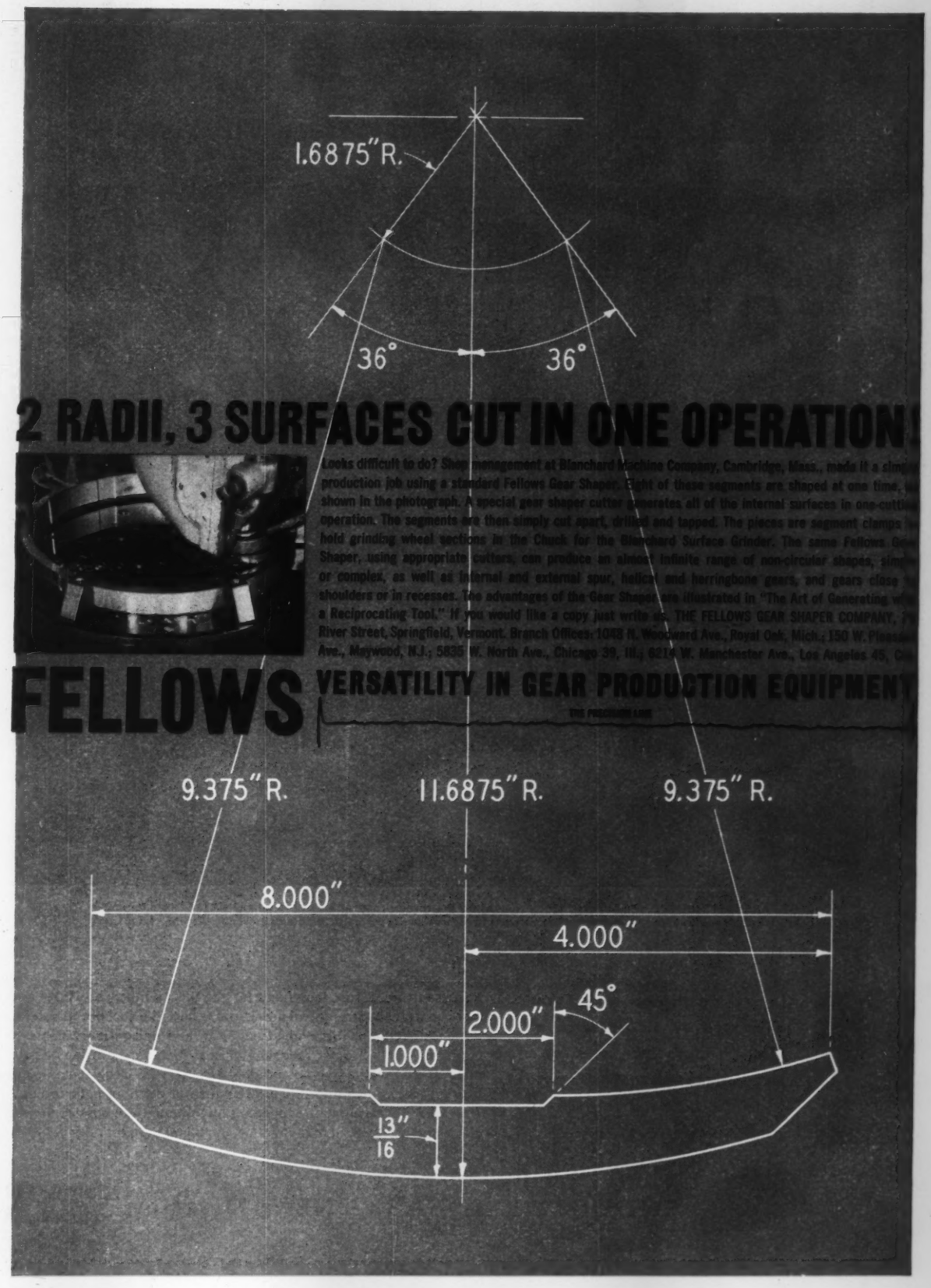
ROTH

RUBBER COMPANY

1860 S. 54th Ave., Chicago 50, Ill.

DIVISION OF VAPOR HEATING CORPORATION

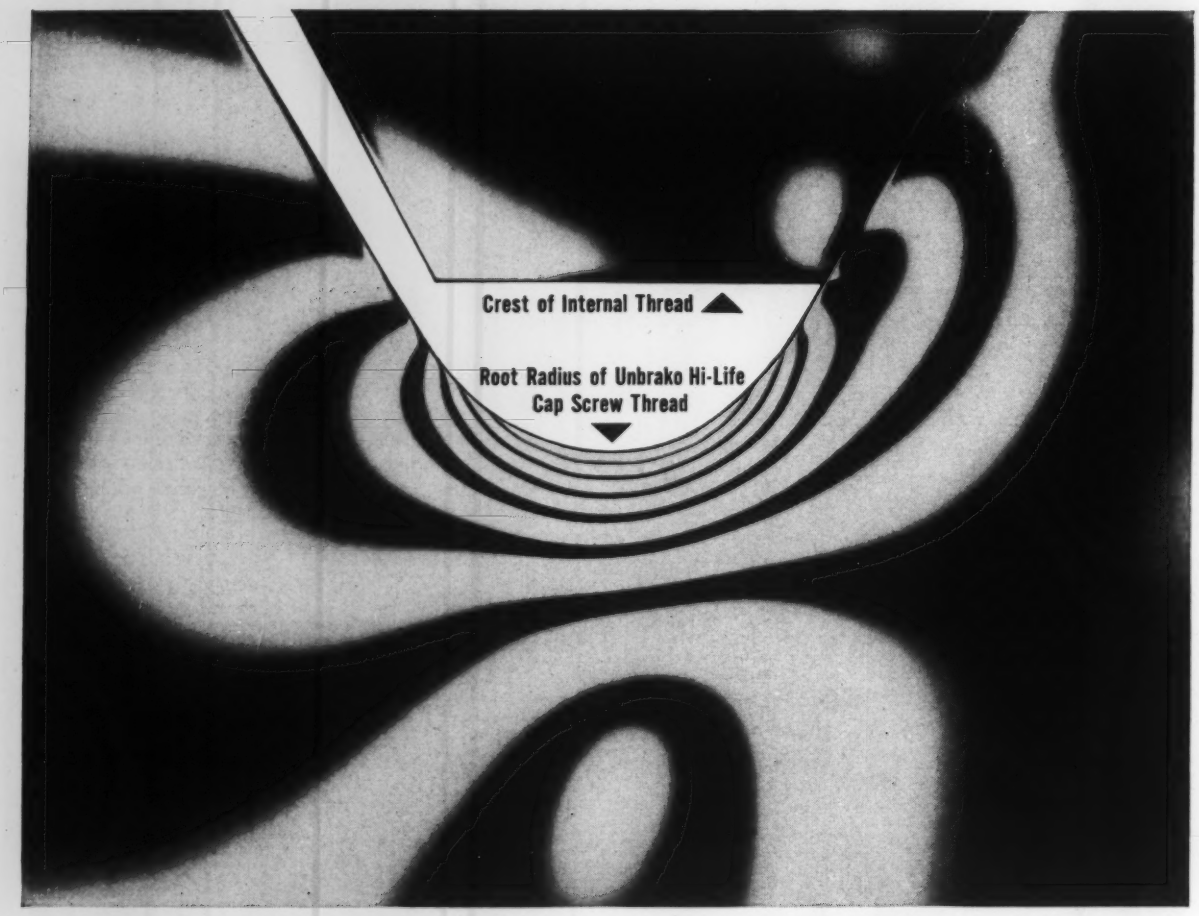
Circle 473 on Page 19



Circle 474 on Page 19

SPS RELIABILITY / *A dynamic standard of predictable performance*

The big change is in the threads



STRESSES ARE DISTRIBUTED. Photoelastic study shows how the thread root radius of the new UNBRAKO Hi-Life socket cap screw blends smoothly into the flanks of the threads to reduce stress concentration and increase fastener fatigue life.

Improved thread root form, developed by SPS research on high-strength fasteners, now standard on all new UNBRAKO Hi-Life socket head cap screws. And at no increase in price.

Radiused thread root lengthens fatigue life as much as 100% and increases tensile strength of new UNBRAKO Hi-Life socket cap screws. For the first time, this high-strength thread design is available to industrial users. Higher reliability of new fasteners provides assurance of longer life for your product. Bulletin 2577 gives complete details. Ask your authorized SPS industrial distributor for a copy. Or write SPS—manufacturer of precision threaded industrial fasteners and allied products in many metals, including titanium.

INDUSTRIAL FASTENER Division SPS

JENKINTOWN 18, PENNSYLVANIA

Circle 475 on Page 19

Circle 476 on Page 19→

For *extra quiet* operation...

WAGNER 10 HP RESILIENT MOUNTED MOTORS

are vibration free··sleeve or ball bearing

Today, many motors are installed in areas where noise must be held to a minimum — in hospitals, churches, schools, office buildings, restaurants and similar locations where quiet is essential or desirable.

Such installations have created a need for larger polyphase motors that are exceptionally quiet and vibration-free. Wagner has filled this need by expanding its line of polyphase resilient mounted motors to include standard ratings through 10 hp.

If you have an application that calls for a smooth running motor, cushioned by resilient mountings, it will pay you to specify these Wagner Motors—a complete range of ratings from 1 through 10 hp.

Constant research and development have kept Wagner up front in electric motor design for more than 65 years—made the name Wagner one you can trust in choosing electric motor drives.

Your nearby Wagner Sales Engineer can help you select the *right* motor to meet your requirements. There are Wagner branch offices in 32 principal cities.

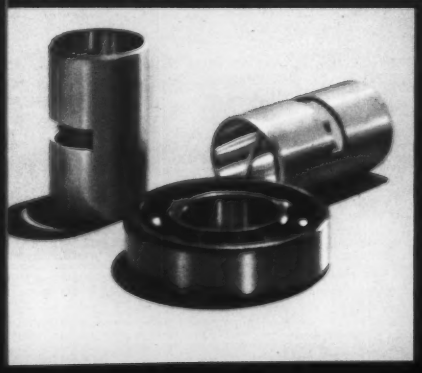
Wagner Electric Corporation

6400 PLYMOUTH AVENUE, ST. LOUIS 14, MISSOURI

SLEEVE OR BALL BEARING. These motors are furnished with quiet running steel-backed babbitt lined sleeve bearings that have high load carrying capacity. Ball bearings can be supplied when desired.

NEOPRENE CUSHIONING RING. Annular mountings, of neoprene bonded to steel rings, cushion the motor in its cradle base to absorb the small amount of vibration that remains in the most carefully balanced motor.

CEILING, SIDEWALL OR HORIZONTAL MOUNTING. You can mount these motors on walls or ceilings by rotating the cradle base 90° or 180°. The motor is designed to remain completely drip-proof in any horizontal position.



Pack MORE POWER Into LESS SPACE

WAGNER CAPACITOR-START MOTORS

PROVIDE DEPENDABLE STARTING...GIVE LONG TROUBLEFREE SERVICE...

OPERATE IN ANY POSITION Here's the single phase general purpose motor that gives quick troublefree starts every time—thanks to a Wagner-designed quick break switch... that has earned the Wagner motor reputation for giving long troublefree service... that permits all angle operation in sleeve bearing fhp models.

Wagner Type RK Motors give more horsepower with less bulk —are ruggedly built to permit direct mounting—are small enough to fit in tight spots. Available in a range from ⅛ through 5 horsepower, with either sleeve or ball bearings, with rigid bases or with resilient mountings for exceptionally quiet operation.

You can get these motors from leading motor distributors in your community or through Wagner Sales Offices in 32 principal cities. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-217 gives full details on Capacitor-start Motors.

Wagner Electric Corporation
6400 PLYMOUTH AVENUE, ST. LOUIS 14, MISSOURI

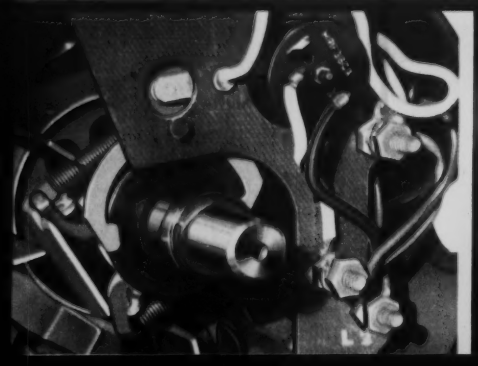
WM59-11

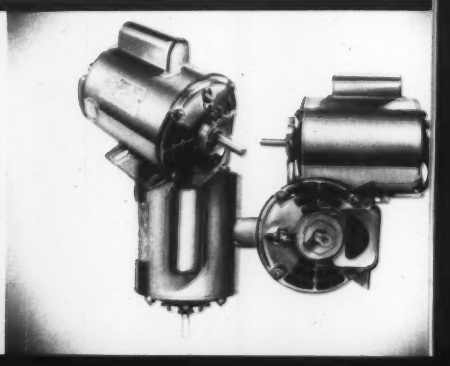
QUICK BREAK SWITCH. The starter is disconnected from the line by this Wagner-designed switch—test proved to make more than a million breaks. (That adds up to two starts per hour for 50 years!)

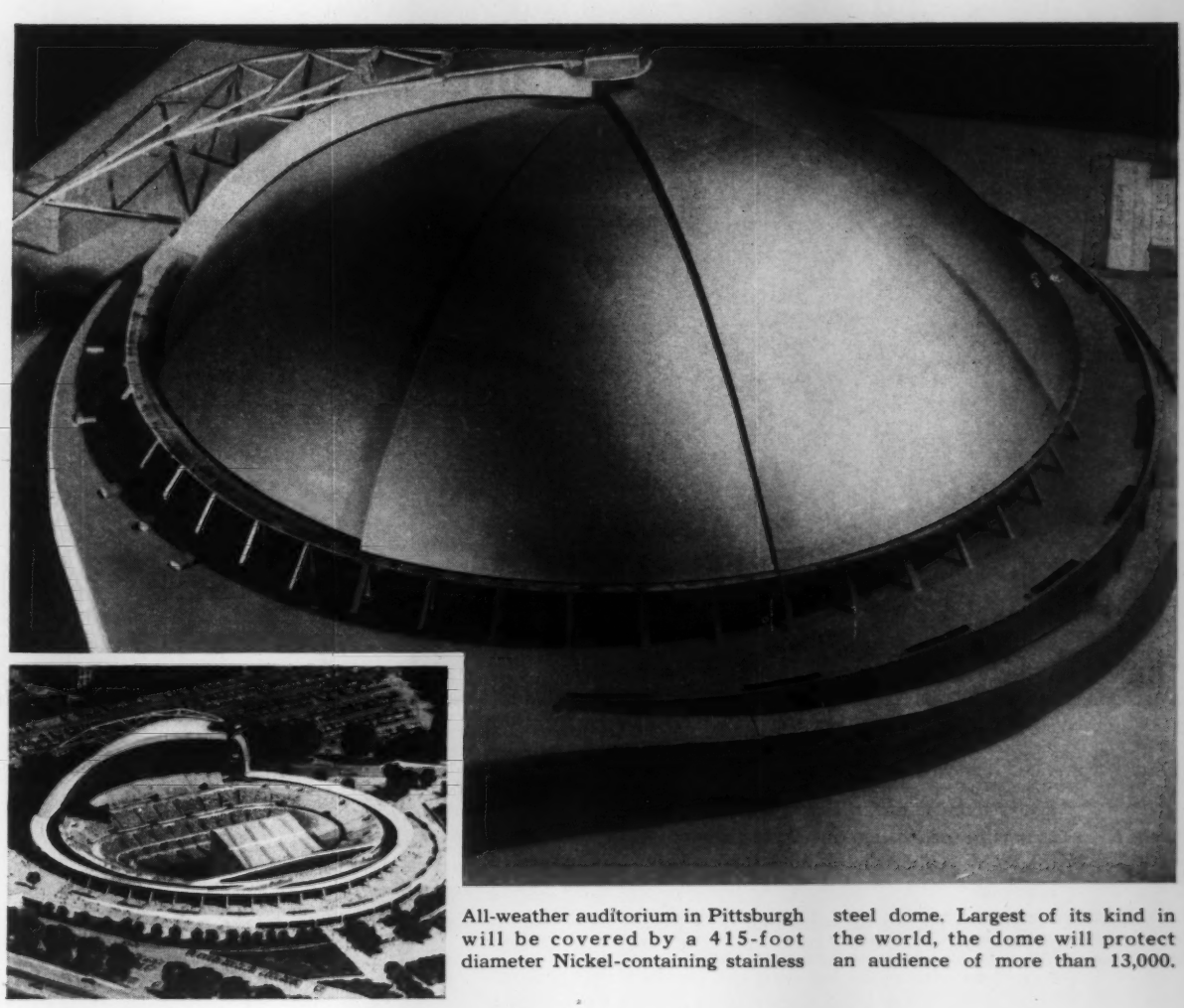
MYLAR* INSULATION. Mylar-paper insulated slot insulation gives excellent protection against moisture, adds thermal stability that gives these motors longer life when unexpected overloads occur.

*DuPont Trademark

ALL-ANGLE OPERATION. The sleeve bearing design, in fractional hp ratings, has a positive lubrication system that permits operation in any position... can mean important savings in motor costs to manufacturers.







All-weather auditorium in Pittsburgh will be covered by a 415-foot diameter Nickel-containing stainless steel dome. Largest of its kind in the world, the dome will protect an audience of more than 13,000.

"Push-button umbrella roof" of stainless steel gives Pittsburgh a new all-weather auditorium

Watching a play or listening to music under the stars heightens the enjoyment. That is, until a passing shower comes along to wash out the fun. But now comes a new idea in auditoriums. In this one, an umbrella roof of Nickel-containing stainless steel will close at the first drops of rain—and on with the show.

It's a simple concept, but a daring one. Eight huge sections nest together when the dome is open. Push a button, and six of these sections glide quietly together around an outside track.

They looked into all sorts of sheathing materials in designing the dome before choosing stainless – a Nickel-containing stainless steel.

For stainless with Nickel in it is one of the most weatherproof metals there is. It is corrosion-resisting all the way through – in salt air as well as industrial atmospheres. What's more, it's virtually self-cleaning – rainfall alone keeps this metal clean.

No wonder you see Nickel-containing stainless wherever strength, long life and handsome appearance are called for! Not only in buildings – inside and out – but everywhere you look.

Suggest something to you? Can stainless help you solve a problem involving corrosion, stress, appearance, temperature extremes? The way to find out is to write us. We'll see if Nickel-containing stainless steel – or some other nickel alloy – may be just what you're looking for.

THE INTERNATIONAL NICKEL COMPANY, INC.

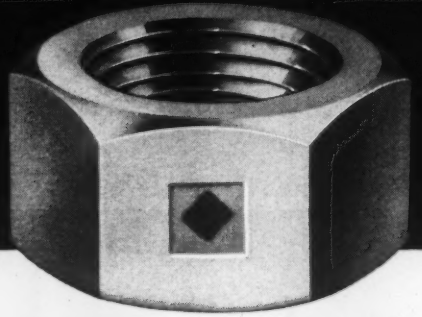
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

Where secure holding power is needed most...

REPUBLIC NYLOK® FASTENERS



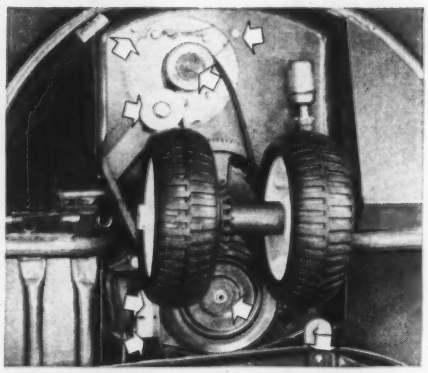
Users from coast to coast know about the quality construction of Roberton Twin Power Riding Mowers, made by Roberton Manufacturing Company, Chicago, Illinois.

Efficient riding mowers like these, constantly used to cut grasses of varying thickness and height, are subject to intense vibration. Yet their *two* power units are firmly held in place for long, dependable service by a total of 44 Republic Nylok Fasteners.

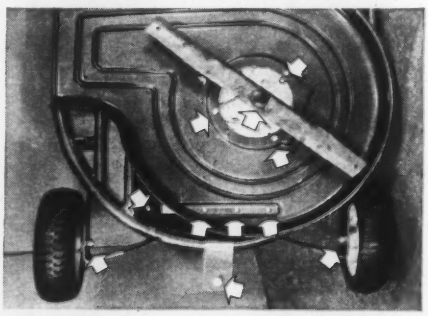
Republic Nylok Fasteners have a special nylon insert that assures positive locking at any position, even under severe shock, vibration, or tension. When the fastener is assembled, this nylon plug exerts pressure in a lateral direction, preventing all play, and utilizing the metal-to-metal contact of the opposing threads for locking.

Republic Nylok Fasteners provide maximum holding power under all conditions, whether seated or not; and they can be used repeatedly. One of their unique advantages is the "plastic memory" of the nylon plug—the tendency of the nylon to recover its original shape after assembly. This "growth" into the threads actually results in a tighter locking action, after a period of time, than when the fastener was first assembled.

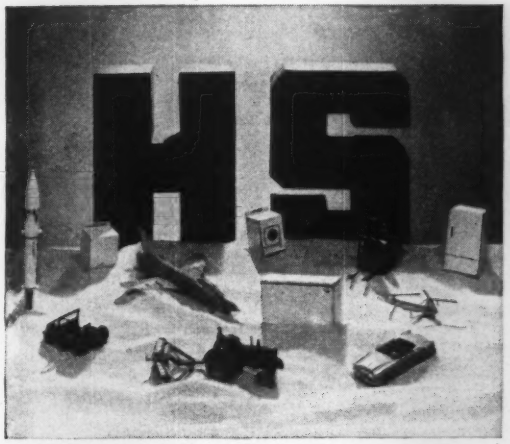
The nylon insert is unaffected by age or cold, has high resistance to heat, and very low moisture-absorption rate. These are but a few of the reasons why Roberton Manufacturing Company uses Republic Nylok Fasteners in its advanced line of power mowers. Advantages like these can pay dividends in *your* application, too. For full information, contact your Republic representative, or mail coupon.



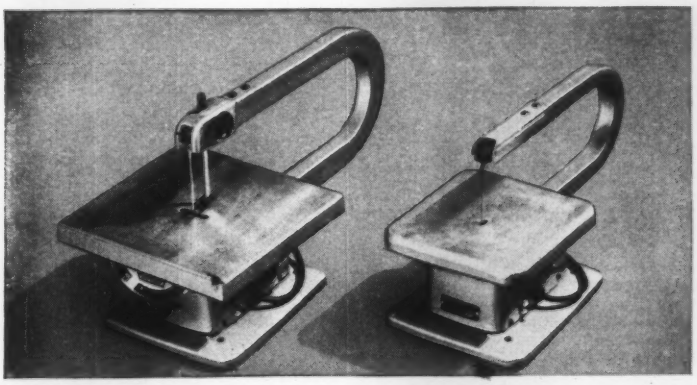
DRIVE UNIT, which furnishes motive power for Roberton Mower is securely held in place by Republic Nylok Fasteners as indicated by arrows. Engine remains tight against base even after years of hard service.



POWER FOR CUTTING is provided by a second, independent engine. Imagine the vibration set up by the swift-moving blade shown. Yet Republic Nylok Fasteners hold engine, wheels, and other parts, firmly in place.



REPUBLIC'S NEW HIGH STRENGTH POWDER, Type HS6460, opens the way to new markets for new applications using sinterings for highly stressed parts. Type HS6460 can be used with existing operating equipment. It provides a minimum tensile strength of 60,000 psi at 6.4 density as sintered, and 100,000 psi heat treated. Type HS6460 maintains its dimensional characteristics after sintering—less than .004 inches per inch shrinkage from die size at 6.4 density. Available in production quantities up to and including 12 tons, or in multiples thereof. Mail coupon for technical data sheet on Type HS6460 Powder.



EASY, EFFECTIVE FABRICATION is a characteristic of Republic Galvannealed Steel Sheets. Severe brake forming, shown above as done by Fogel Refrigerator Company, Philadelphia, does not affect their corrosion-resistant, paint-adhering qualities. Republic Galvannealed Sheets readily take shearing, punching, spot welding, and many other fabricating operations. Mail coupon for more facts.

SAVINGS IN A KEY PART are realized by Syncro Corporation, Oxford, Michigan, by using Republic ELECTRUNITE® Mechanical Tubing in the manufacture of jigsaws. Previously they used a casting for the blade-yoke, which requires a severe bend. ELECTRUNITE Square Tubing was recommended for one model, rectangular tubing for the other. Results: reduction in weight of the blade-yoke, and improvement in appearance of the product, with savings in time, materials, assembly, and shipping costs. For more information mail coupon below.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT.MD-8003 R
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send additional information on the following:

☐ Nylok Fasteners ☐ Galvannealed Sheets
☐ Type HS6460 Powder
☐ ELECTRUNITE Mechanical Tubing

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 477 on Page 19

"How To Specify Solenoid Valves"

An authoritative booklet, fully illustrated with page after page of schematics, flow charts and diagrams, covering every important solenoid valve design. A complete guide for calculating flow and pressure drop characteristics...how to determine the most suitable valve configuration...what type of sealing principle is best for you...how to eliminate costly over-specifying. Invaluable to engineering and purchasing personnel.

Write today for your free copy.

VALCOR
SOLENOID VALVES

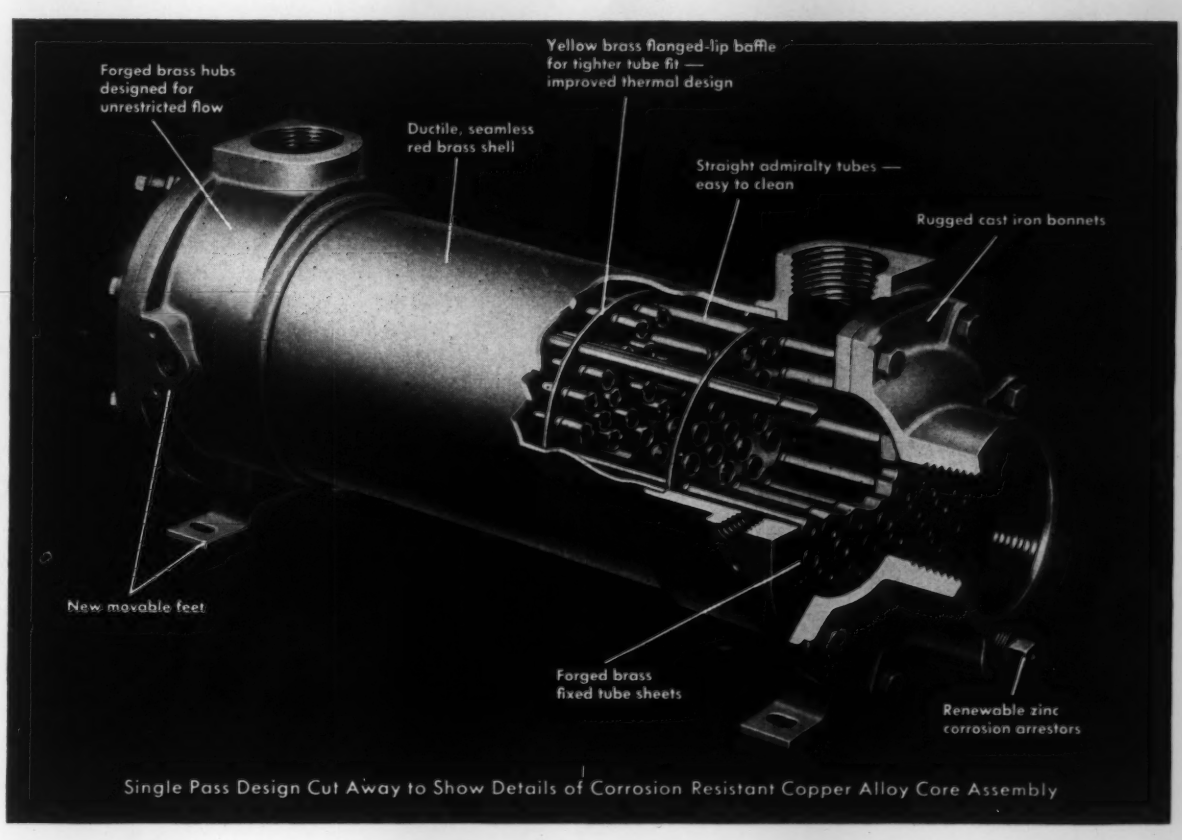
VALCOR ENGINEERING CORP.

5365 Carnegie Ave., Kenilworth, N. J. • CHestnut 5-1665

Circle 478 on Page 19

LOOK AT THE LEADER'S LATEST . . .

New design of a famous line . . . Ross BCF Exchangers



Single Pass Design Cut Away to Show Details of Corrosion Resistant Copper Alloy Core Assembly

LOOK AT THE LIST . . . new design features, new sizes, new capacities, new mountings, new materials . . . *new low prices!* The leader and originator of small, compact, fully standardized exchangers takes another step forward.

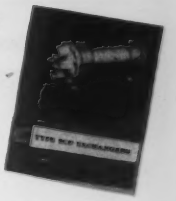
Ross Heat Exchanger (now part of American-Standard* Industrial Division) originated the whole BCF idea 15 years ago. Before then, pre-engineered design, mass produced parts and stocked assemblies were untried for a unit of this type. Designers and users of original equipment were quick to adopt the BCF as standard. Today, on a larger scale than ever, it is cooling lube oil, jacket water, hydraulic and other fluids for a wide variety of industries.

But, even with such success, the BCF has never been permitted to stand still. Ross has persisted in making constant design refinements and performance improvements . . . *the latest are typical: New* baffles with flanged lip at each tube hole and around outer edge for tighter fit and improved thermal characteristics. *New* stamped steel feet, movable in three positions around hubs for easy, more adaptable mounting. *New* sizes and capacities . . . 46 models . . . one, two or four pass designs . . . giving greater selection than ever before.

*American-Standard and Standard ⓐ are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard
INDUSTRIAL DIVISION
AMERICAN BLOWER PRODUCTS • KEWANEE PRODUCTS • ROSS PRODUCTS

Look at the leader's latest. Send in the coupon below for the new Ross Bulletin . . . an up-to-date run down on the new Ross Type BCF Exchanger.



Mail this coupon for new Ross Bulletin

MD3559

To: American-Standard
Industrial Division
Detroit 32, Mich.

Please send, without obligation, your new Bulletin 1.1K6 describing the new Ross Type BCF Heat Exchanger.

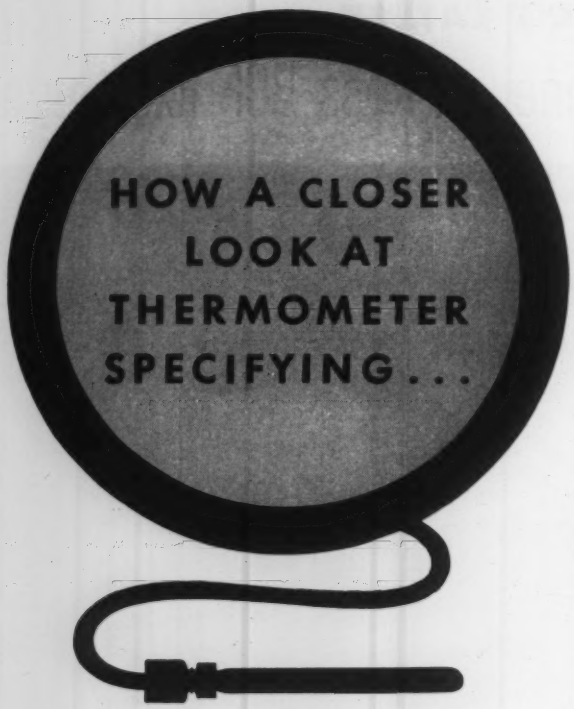
NAME _____

TITLE _____

COMPANY _____

ADDRESS _____

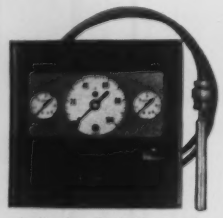
CITY _____ ZONE _____ STATE _____

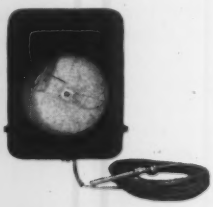


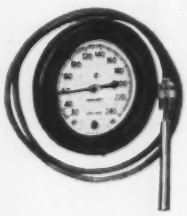
can give you a competitive edge on costs

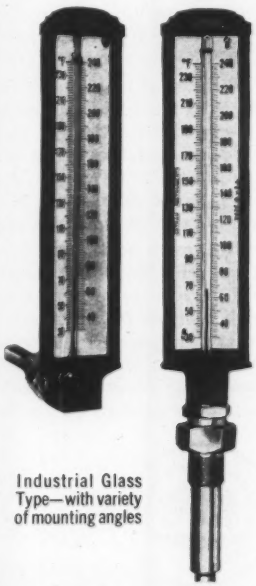
A closer look, for example, at what is available today in thermometer design, performance, accuracy . . . including a closer look at price! Specifically, a closer look at the quality and comprehensiveness of the thermometer line of United States Gauge. Here you will find thousands of standards and specials ranging up to the highest degrees of accuracy . . . in all sizes and styles for all purposes, with exactly the performance you want for your equipment and price. USG thermometers are backed by 54 years' experience in the manufacture of high-precision measuring instruments *which are specified by 6 out of 10 original equipment manufacturers today*. To check on the competitive edge you can get in thermometers, call your nearest USG distributor, listed in the Yellow Pages. Or write direct to United States Gauge.

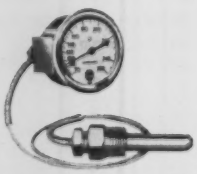
UNITED STATES GAUGE
Division of American Machine and Metals, Inc., Sellersville, Pa.


Indicating Controllers and Transmitters


Recorders and Recorder-Controllers

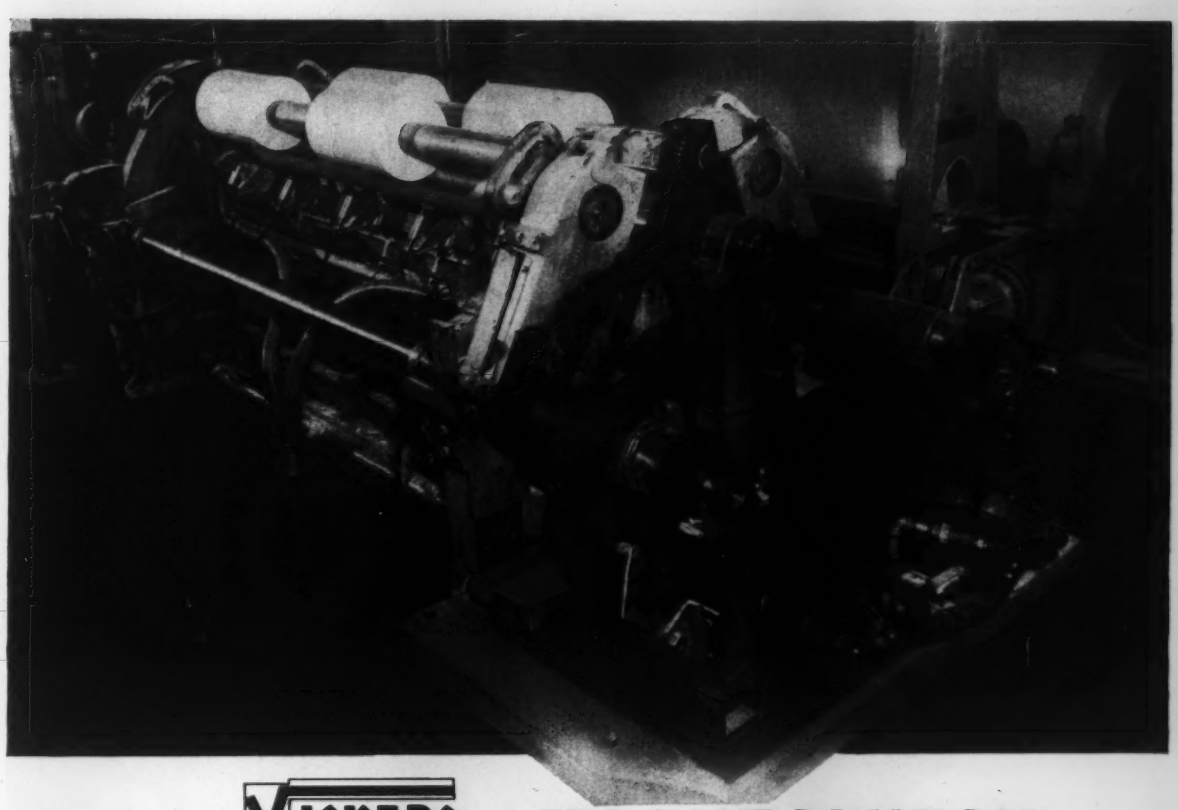

Supertherm® Dial Type


Industrial Glass Type—with variety of mounting angles


Drawn Case Thermometer (Brass or Steel)

Direct-Connected Types

Dial Type with Alarm



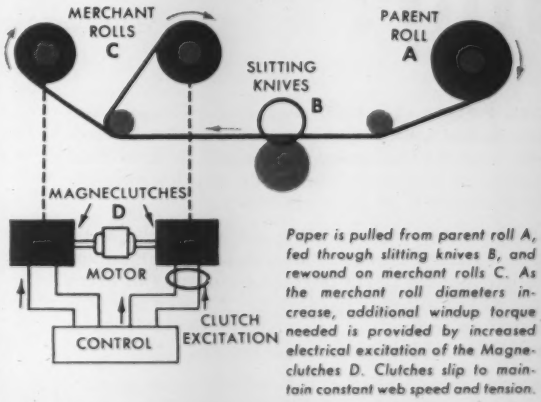
How the VICKERS® MAGNECLUTCH® CONTROLS TENSION...PREVENTS BREAKDOWN on this high-speed paper slitting machine

The smooth, trouble-free operation of this slitting machine of a well-known paper converter demonstrates another practical use of the Vickers Magneclutch, the dry magnetic particle clutch.

Two water-cooled, 200 lb-ft, 6-2-6 Magneclutches maintain uniform tension on the fast-moving web as it is unwound, slit and rewound. Strain, breaking or snarling of the paper is eliminated, downtime is prevented.

The Magneclutch is designed to provide precise regulation and transmission of torque, without grab or chatter. Torque responds quickly, is unaffected by temperature or humidity; water-cooled design dissipates slip heat rapidly; and since there is no wear on torque transmitting surfaces, service life is extremely long. Torque transmission, regulated by energizing current only, is independent of speed, and is easily and remotely controlled.

Write for Descriptive Bulletin on The Vickers Magneclutch



Paper is pulled from parent roll A, fed through slitting knives B, and rewound on merchant rolls C. As the merchant roll diameters increase, additional windup torque needed is provided by increased electrical excitation of the Magneclutches D. Clutches slip to maintain constant web speed and tension.

ELECTRIC PRODUCTS DIVISION VICKERS

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION

EPA 6100-2

ELECTRIC PRODUCTS DIVISION
1881 LOCUST STREET • SAINT LOUIS 3, MISSOURI

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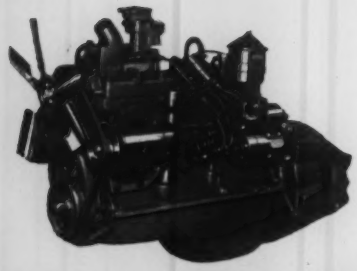


IND. 32 (6)
265 cu. in.
displacement

DEMAND
for
CHRYSLER POWER
at all
time highs

IND. 56-A (V-8)
354 cu. in.
displacement

Why?

- *More power per cubic inch displacement*
- *Longer engine life*
- *Service and parts available within 8 hours*

MORE POWER. Chrysler Industrial Engines develop more horsepower per cubic inch displacement than rival engines. Chrysler's famous fluid coupling and torque converter handle extreme load demands with peak efficiency.

LONGER LIFE. Full filtering oil system, special hardened crankshaft and bearing material, superfinished moving parts provide thousands of extra hours of trouble-free operation. Chrysler power is tailored to individual applications through thousands of combinations of options and accessories.

SERVICE. New Chrysler industrial engine centers and dealer network virtually eliminate down time losses. Parts and service available anywhere in the United States within 8 hours. The fastest, most efficient service in the industry.

Investigate big output Chrysler Industrial Engines for power in the 230 to 354 cu. in. displacement range. Discover what Chrysler engines can do for your product!

NEW Chrysler Product Line Catalog gives complete details on all engines, all optional equipment. Enables Chrysler sales engineer to "build" and price an engine for your individual application—right at your desk. A call or letter will bring a Chrysler sales engineer to your office.

NOW AVAILABLE FROM CHRYSLER—
DIESEL ENGINES, 9 to 300 h.p. (16 models)

CHRYSLER

MARINE AND INDUSTRIAL ENGINE DIVISION
CHRYSLER CORPORATION · DETROIT 31, MICHIGAN

Circle 482 on Page 19

Some Ideas

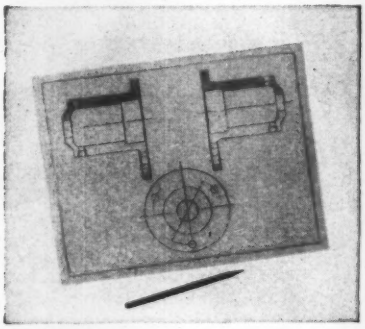
for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

A year of relentless testing has produced a small library of interesting facts about HERCULENE (T.M.) Drafting Film. What follows is a consensus of drafting-room experience with HERCULENE—by K&E and its customers—with some up-to-date recommendations for using it. Take the matter of . . .

Shiny Back vs. Pencil Back

A basic question is: do you need a double-surfaced drafting film? We make HERCULENE Drafting Film both ways, of course —with a single surface (shiny back) and double surface (pencil back). It's our recommendation that you use pencil back HERCULENE only if it's your practice to make basic drawings on one side, changes on the other. For most other uses, shiny back is preferable. (At first, the double-surface film was chosen by many drafting rooms because it lay flatter on the board than shiny back. This is no longer true. K&E research labs have come up with a fully effective anti-curl treatment.) Especially in filing, shiny back HERCULENE presents fewer problems. The clean non-abrasive back won't smudge the face of the sheet underneath, even in a heavy stack of tracings. If you'd like to compare a few sheets, please let us know.



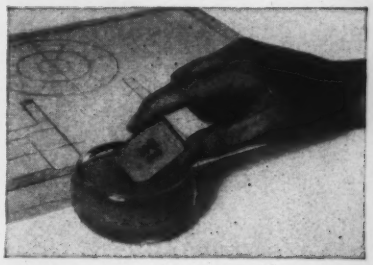
Note sharp clear lines made by Duralar pencil on HERCULENE Drafting Film.

Plastic Pencils and the HERCULENE Surface

Not just a handy catch-phrase, when K&E puts its exclusive "engineered surface" on a drafting material, the result is an exact, uniform tooth for sharp pencil drawing, inking and typing. With HERCULENE Drafting Film, however, an entirely new type of plastic (non-graphite) pencil yields especially good results. Quite a few of our customers have reported favorably on the well-known Staedtler "Duralar" brand. Duralar pencils come in five hardnesses, are non-smudging and have generally good covering power, sharpness and erasability. After about 20 prints, the Duralar lines show up consistently better than those made by a regular pencil, since graphite lines tend to lose density.

Wet That Eraser!

The erasing qualities of HERCULENE Drafting Film are excellent, but (as with the pencils) we've discovered it's a new type of vinyl eraser that gives the best results. Examples of these non-rubber type erasers are the Richard Best "TAD" and the Eberhard Faber "RACE KLEEN" – both available from your K&E dealer. With vinyl erasers, pencil lines whisk off. Even stubborn ink and typing can be removed easily, with no damage to the surface. Here's a tip on how to do this:

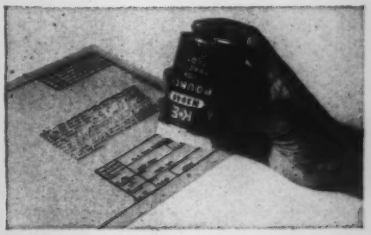


Moisten the eraser slightly. It becomes no more abrasive, but a lot more "erasive." Moistening is a must when removing Duralar lines or typing after exposure to heat. (Incidentally, don't use electric erasing machines, steel erasers or typewriter erasers.) When erasing large areas, certain chemical eradicators work fine too. Our suggestion: use Vythene or a very light application of a denatured alcohol such as Solox, both of which can be applied with a cotton swab or clean cloth.

The Cleaner the Better

HERCULENE Drafting Film was designed for ink work, and its ink take is unexcelled. But like all films, its non-absorbency makes a few preparations advisable. The surface should be cleaned thoroughly before inking. Quickest and most effective way to do this is with the ABC Draftsman's Dry-Clean pad, which will remove finger marks and "traffic film" simply by rubbing the pad over the surface. Pouncing will also work well. A damp cloth is all right for general cleaning, but does not do the best job of preparing the surface for ink.

Inking over graphite pencil lines comes out best when done over light lines, drawn with a harder grade of pencil. A good way to remove excess graphite is to go over the drawing with an ABC pad. Inks vary in their usefulness on HERCULENE. We've tested several, and you're welcome to these results as well, on request.



After Typing, Please Pounce

Typed impressions on HERCULENE Drafting Film are crisp and sharp, but may take a while to dry because the film's surface doesn't "swallow" ink readily. A light pouncing right after typing will dry the ink and fix the lines – giving you uniform permanent contrast.

A new typewriter ribbon will produce the best impressions. At K&E we've tested a healthy variety of ribbons and we'd be pleased to send you the results on request.

Outstanding Advantages Proved in Tests

We're pleasantly amazed at the short time it took for HERCULENE Drafting Film to become an accepted "staple" – along with ALBANENE® Tracing Paper and PHOENIX® Tracing Cloth. Actually, it's a rare drafting room by now that has *not* tested HERCULENE during its first year on the market. The findings: All properties considered, HERCULENE stands up better than any other drafting film. It has great resistance to heat, aging and abuse. Its exclusive "engineered surface" plus its tough, durable Mylar® base provide superior pencil and ink take, fine erasability, remarkable dimensional stability...a combination we're proud to call unbeatable!

The K&E dealer near you has HERCULENE now. Stop in and see him.

KEUFFEL & ESSER CO., Dept. MD-9, Hoboken, N. J.

Please send further information about HERCULENE Drafting Film. I'd like samples too.

Name & Title _____

Company & Address _____

_____

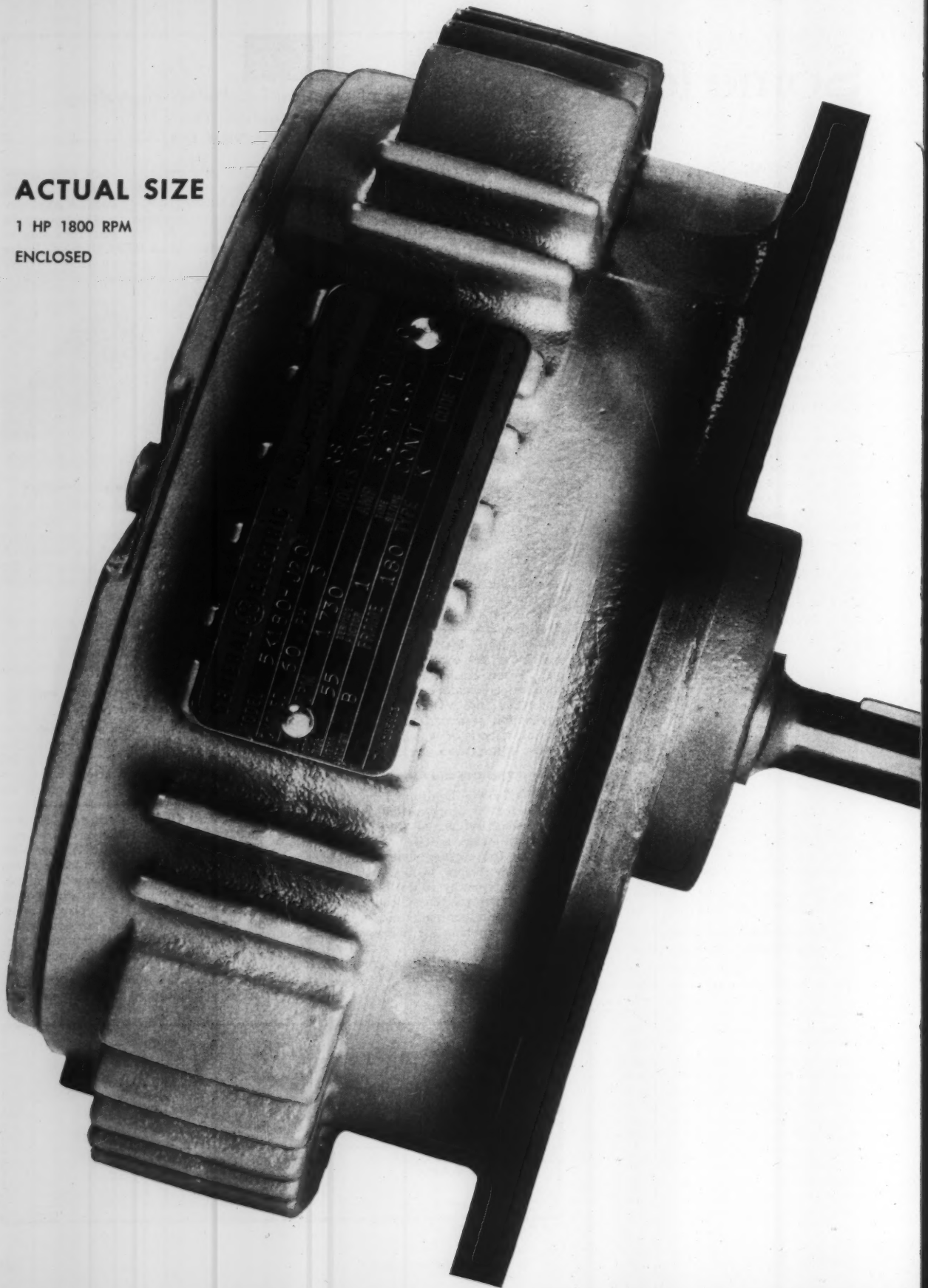
2001

Circle 483 on Page 19

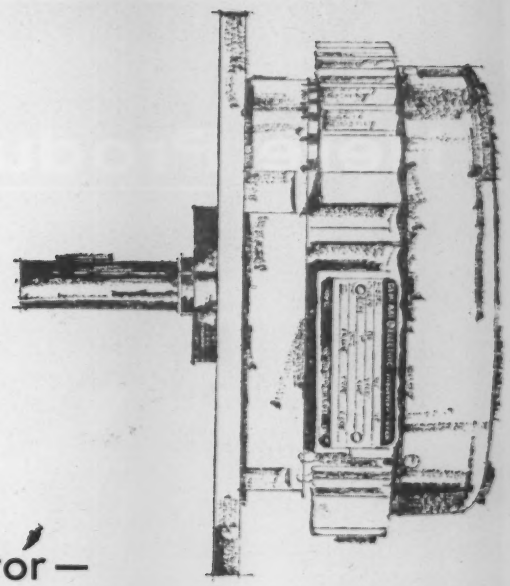
ACTUAL SIZE

1 HP 1800 RPM

ENCLOSED



NEW



General Electric Thinline Motor—

SHORT, LIGHT AND VERSATILE

You can easily eliminate one of your motor installation problems with General Electric's new polyphase motor for limited-space mounting.

Up to eight inches shorter and 26 pounds lighter than standard flange-mounted motors, General Electric's new Thinline motor will let you meet your horsepower requirements in considerably reduced installation space. By getting more horsepower in less space, you will be able to design more compact equipment in the future. On your present equipment, the Thinline motor's smaller overhang reduces required equipment space or gives operators more working area.

Easier to handle and position during installation, the Thinline motor minimizes mounting problems. Your assemblers will be able to work faster with less fatigue. And the 26-pound weight reduction lets you save substantially on shipping costs!

A wide choice of enclosures and mounting dimensions adds versatility to the Thinline motor's flange-type design. Thinline motors are available from 1 to 5 HP in both dripproof and totally-enclosed constructions.

Mounting versatility is provided by your choice of *three* mounting flanges for each Thinline motor rating. Any of the three available flanges (see the chart below) can be used for all-angle mounting—without adding to motor length.

You can get the answer to your Thinline motor application question simply by calling your nearby General Electric Apparatus Sales Office. If you have not received your copy of General Electric's Thinline motor publication, write to Section 840-28, General Electric Co., Schenectady, N. Y. Ask for Bulletin GEA-6927.

INTERCHANGEABLE FLANGE DIMENSIONS

Horsepower at 1800 rpm	Outside Diameter of Flange in Inches		
	Standard	Modified "D"	Alternate
1 hp	10.25	11	12
1½ and 2 hp	12	11	10.25
3 hp	13	11	14
5 hp	14	11	13

KNOWN APPLICATIONS

Fans and Blowers
Food Machinery
Textile Machinery
Floor Machinery
Paper Machinery
Pumps and Compressors
Machine Tools and Metalworking Machines

Progress Is Our Most Important Product

GENERAL ELECTRIC

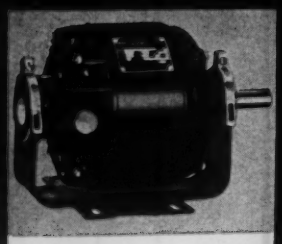
Circle 484 on Page 19

Here Production Counts...

For eggs, there is no finer production facility than a hen. And, for production facilities unrivaled in the appliance and equipment motor field, look to Emerson-Electric.

Remember . . .

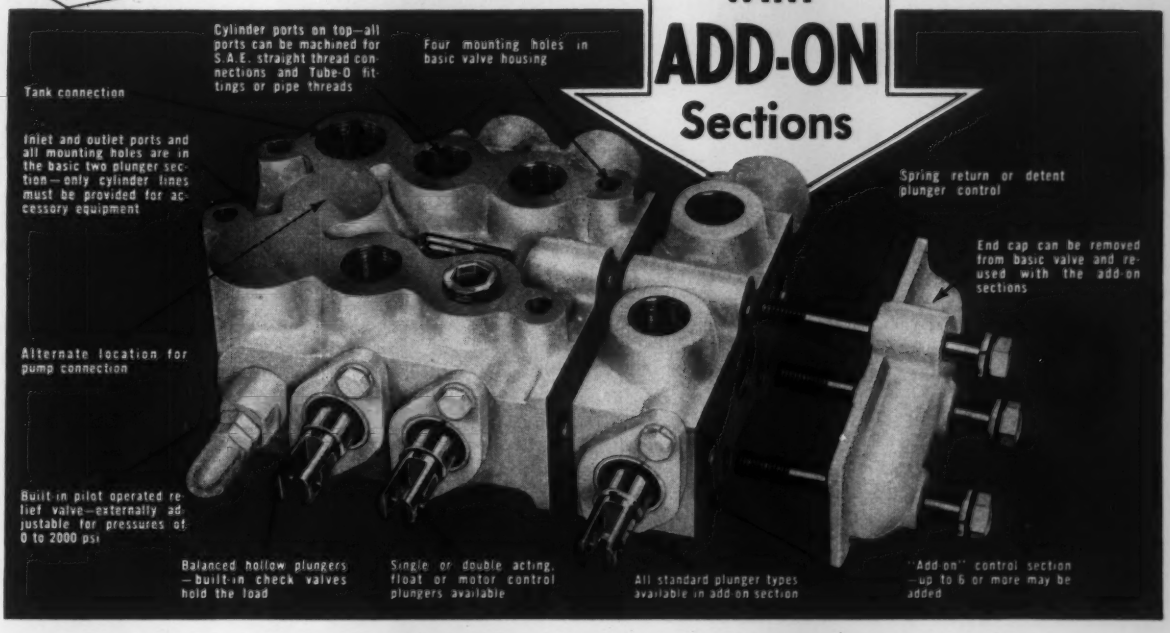
- Emerson-Electric's unique production facilities assure you *on-time* deliveries.
- We produce *custom-engineered* motors to suit *your specific needs.*



Put more than 65 years of experience to work for you. Call, wire or write Dept. M388 today. The Emerson Electric Mfg. Co., St. Louis 21, Mo.

EMERSON-ELECTRIC *of St. Louis · Since 1890*

new HYDRECO® CONTROL VALVE with ADD-ON Sections



V-34 Series—for Field Mounting of Accessory Equipment on LIFT TRUCKS • INDUSTRIAL LOADERS • FARM MACHINERY

The HYDRECO V-34 Series "ADD-ON" type Valve, recommended up to 20 gpm operation and 2000 psi, has a basic 2-plunger cast-in-block section to which additional control sections (up to 6 or more), may be added at any time.

All mounting holes, tank and pump connections and relief valve are located in the basic section . . . control functions for added accessory equipment can be provided without disturbing the original installation.

V-34 "ADD-ON" sections are pre-tested. They are packaged for easy installation in the field or in the shop.

In the Field . . . Equipment dealers have a more salable accessory package with lower installation costs and better service to the customer.

In the Shop . . . Accessory equipment can be added to machines on the floor quickly and at low cost when HYDRECO V-34 Valves are on the original installation. Deliveries are expedited . . . inventories reduced. Only one reservoir or mounting configuration required for any number of control plungers.

V-34 SERIES VALVES FEATURE THESE ADDED ADVANTAGES:

- Low pressure drop through the cylinder circuit and the open center . . . V-34 Valves handle more than rated capacity with little loss in efficiency.
- Small in size and easy to install . . . no special fittings needed.
- Exceptional throttling and operator control . . . important for load lifting equipment.

HYDRECO DIVISION
THE NEW YORK AIR BRAKE COMPANY
9006-9 EAST MICHIGAN • KALAMAZOO • MICH.

Please send me information on the New HYDRECO V-34 Valve.

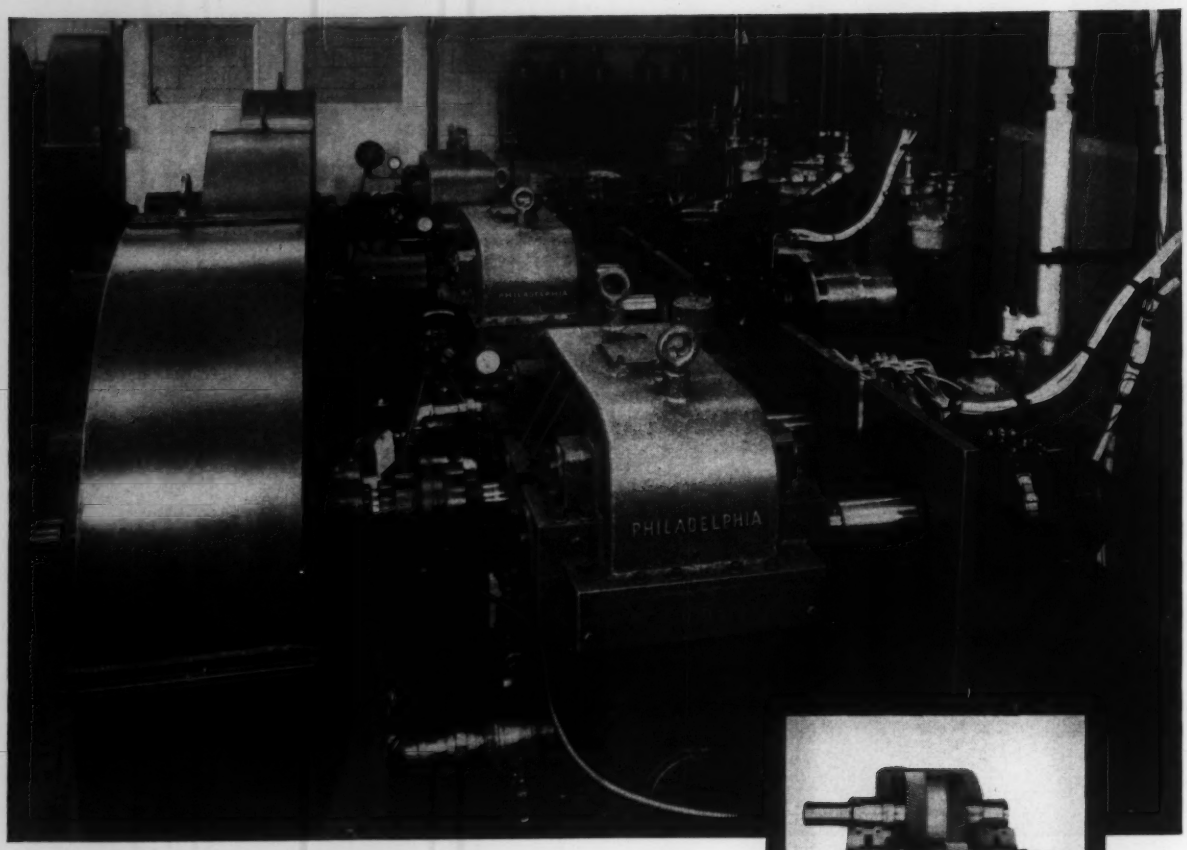
Name_____

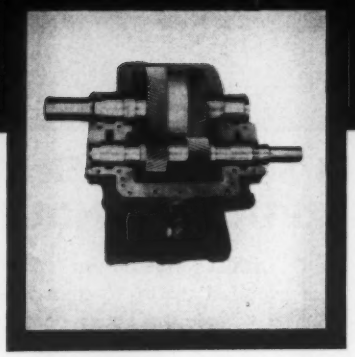
Company_____

Address_____

City_____ Zone_____ State_____

Circle 486 on Page 19





PHILADELPHIA HI-SPEED INCREASERS drive simulated "test flight on ground"...

Testing of jet aircraft electrical power systems calls for exact duplication of tortuous flight conditions in the lab . . . *complete to supersonic speeds!* At General Electric Aircraft Systems Engineering Laboratory above, three Philadelphia speed increasers drive generators for simulating conditions of both low inertia, high acceleration reciprocating engines and high inertia, low acceleration jet engines. Each stand is powered by a 200 HP DC motor coupled to a Philadelphia 5.8:1 speed increaser. The drive system provides for adjustable speed at rated continuous power from 4000 to 12000 rpm with overload capacity of 300 HP for five minutes and 400 HP for five seconds.

To meet these exacting requirements for performance and continuous operation, Philadelphia HI-SPEED drives offer exclusive advantages in drive design . . . advantages you can't get anywhere else. Double opposed helical gearing is precision hobbed, precision tooth ground and dynamically balanced. Symmetrically arranged gearing balances loads on bearings and shafts. Shaft deflection is minimized . . . bearings last longer.

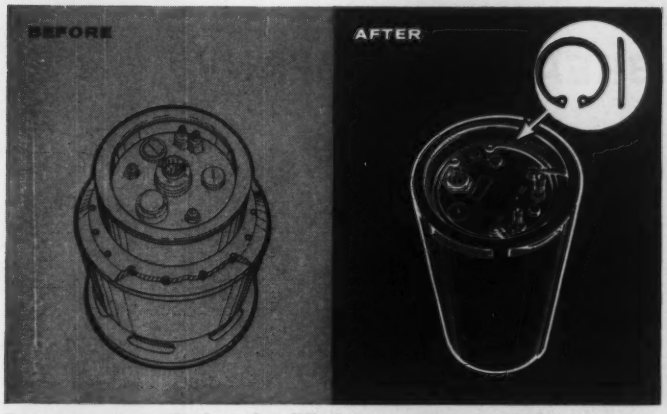
Philadelphia HI-SPEED Drives are available in standard units for speeds to 10,000 rpm at pitch line velocities to 10,000 fpm. 1 to 7100 HP. Ratios from 1:1 to 10:1 for high speed reduction or increase. Special HI-SPEED drives are furnished for higher speeds, horsepowers and ratios. Write today for your copy of our HI-SPEED catalog.

PHILADELPHIA GEAR CORPORATION
Erie Avenue and "G" Street, Philadelphia 34, Pennsylvania

philadelphia gear drives

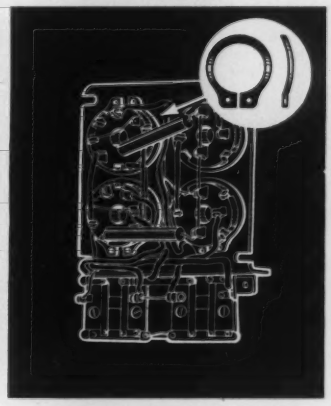
Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

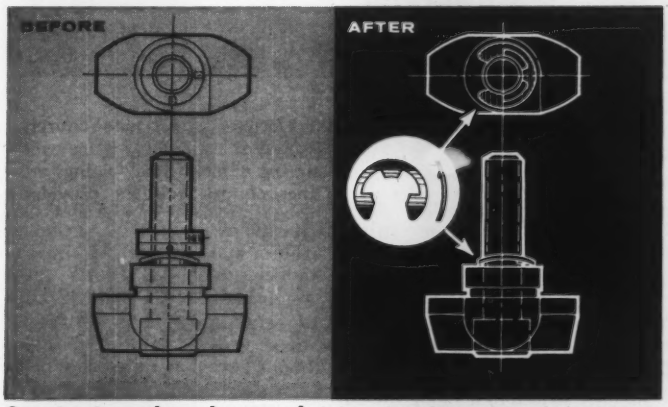


Pressure cover design simplified. Two axially assembled Truarc Series 5002 beveled rings eliminate 27 bolts, reduce machining and assembly time from 78 to 1½ hours and make possible drastic size and weight reductions. Rings retain two covers of a pressurized x-ray unit. **Savings: about $500 per unit.**

Parts eliminated in slide assembly. Two radially assembled Truarc Series 5139 Prong-Lock® Rings provide proper spring tension, eliminate looseness and wobble in this office calculator shift-slide. Original design called for a cut washer, spring washer, and cotter pin—all eliminated.



New way to install electron-tube sockets. Easy-to-apply Truarc Series 5101 bowed external rings lock tube sockets to chassis plate in this assembly. Bowed construction takes up tolerances of molded grooves, thickness of base. Individual sockets are removable for field service.



Quarter-turn clamp improved. A bowed washer and two locknuts were eliminated in this quarter-turn jig-and-fixture clamp by a Truarc Series 5131 bowed E-ring. The radially assembled ring holds the screw captive, provides required rotational drag between parts with sufficient tension to insure tight fit when the screw is first engaged. **Typical savings: $1.35/unit—assembly up 70%.**

Truarc rings for end-play take-up offer significant design advantages

A number of Truarc retaining rings are available to take up end-play or loose fit caused by accumulated tolerances and wear. The rings often eliminate spring washers, collars and set screws, nuts, bolts, rivets, cotter pins and other conventional fastening devices with outstanding cost savings in machining and assembly time.

Truarc retaining rings designed to deal with the end-play problem are of two general types: **bowed rings** for resilient end-play take-up and **beveled rings** for rigid end-play take-up.

Bowed retaining rings are widely used for preloading bearings, preventing vibration or oscillation in linkages, providing tension on adjusting screws. Of particular interest is the radially installed Truarc Prong-Lock® ring which locks securely to the shaft by means of two prongs. It provides exceptional thrust load capacity, may be used as a shoulder against rotating parts, and often eliminates springs, bowed washers and other tensioning devices.

In beveled rings for rigid end-play take-up, the groove-engaging edge is beveled at 15°. There is a corresponding bevel on the load-bearing groove wall. To take up end-play, the ring acts as a wedge between the outer groove wall and the part being retained.

These are just a few of the 50 functionally different types of Truarc retaining rings. They come in up to 97 standard sizes, six metal specifications, 13 different finishes. The entire line as well as accessory assembly tools, grooving tools, and over 70 typical applications are shown in the new catalog RR 10-58. Write for your copy today. And remember Waldes Truarc engineers are always ready to work with you on your specific projects. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N.Y.

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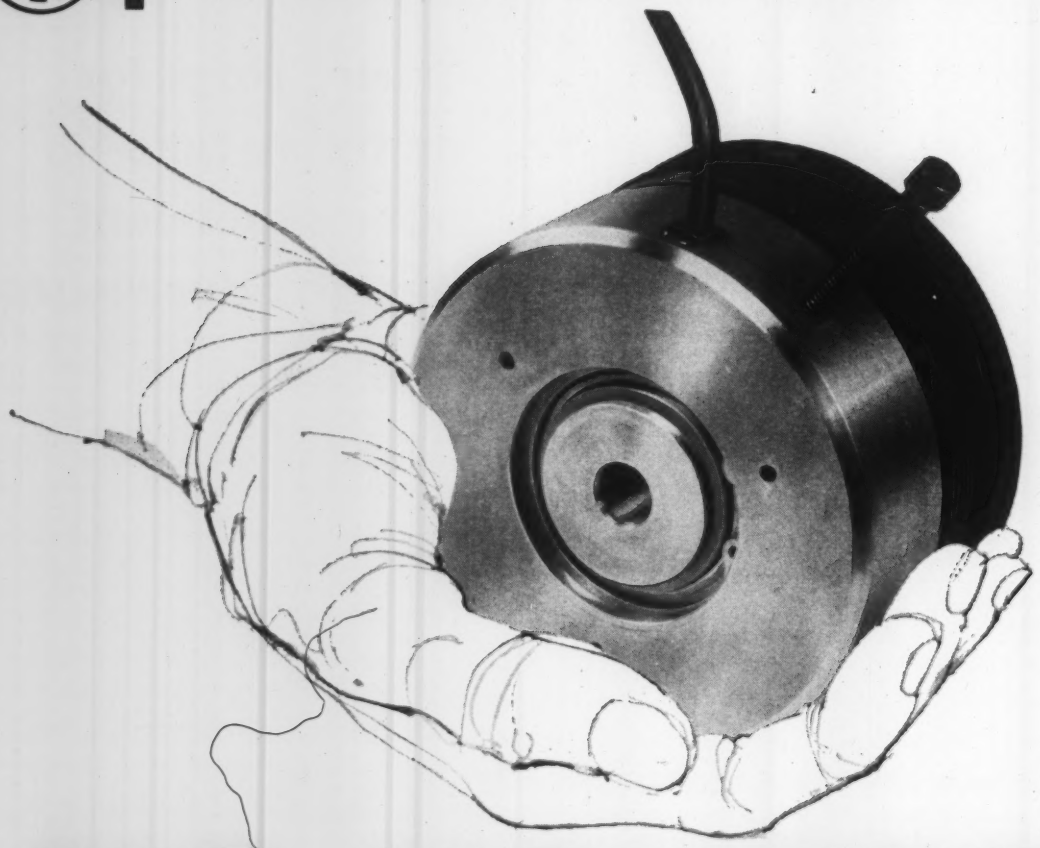
WALDES
TRUARC®
RETAINING RINGS
Waldes Kohinoor, Inc., Long Island City 1, N.Y.

TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

I-T-E CIRCUIT BREAKER COMPANY



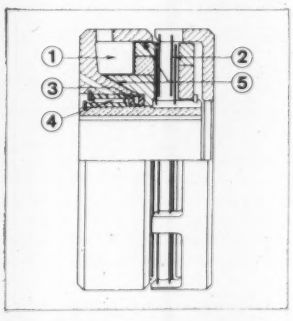
NO UPKEEP

New I-T-E Electro-Clutch with stationary field never needs maintenance of any kind!

In addition to greater compactness than any other clutch, now the I-T-E Electro-Clutch* is available with a tremendous new advantage: no upkeep. This new design has a stationary field that does away with the slipring and brush. So you are forever relieved of the problem of cleaning or replacing brushes. And of course there never was any other maintenance required . . . no air gap adjustments or friction surfaces to replace.

Elimination of upkeep means designers can bury the I-T-E Electro-Clutch inside a drive box or transmission . . . for access is never needed. It's a component that can be installed and practically forgotten. Roller thrust and needle radial bearings keep friction down and clutch size to a minimum . . . plus insuring long, efficient life.

Installation during machine assembly is simpler too. The clutch is delivered completely assembled. You merely slide it onto the shaft. This new I-T-E Electro-Clutch is made entirely in this country. So you are assured of availability. Same wide range of torque ratings as slipring models. Stock ratings are for 24 or 90 volts d-c. Other control voltages provided on request.



Cutaway view shows these details: (1) stationary coil windings that generate the field; (2) hardened steel clutch laminations that operate in an oily atmosphere and maintain constant torque rating without adjustments throughout life; (3) roller thrust bearings; (4) needle radial bearings; (5) air gap that never needs adjusting.

*PATENTS APPLIED FOR

in
forgings...

d'ARAZIEN

Alcoa puts the metal where you want it

More than a hundred tons of Douglas DC-8 kiss the runway on forged aluminum wheels like this one. Strength and lightness are obvious requirements. Even more essential is reliability through landing and after landing to guard the safety of passengers and crew.

Logically enough, rugged aluminum forgings were elected for the job. Then came many hours of Alcoa skill in die design, demonstrated in the remarkable zebra stripes visible in the cross section. They represent the aluminum grain flow* and illustrate how the tough aluminum grain is forged to withstand the shock loads of landing impact, plus the cyclic fatigue of rotation, all with a wide margin of safety.

Alcoa forges these wheels with a unique combination of blocker and finishing dies to put the metal exactly where it's needed. Alcoa Alloy 2014-T6 assures excellent machinability for the designer and producer, Bendix Products Division, Bendix Aviation Corporation. And Alcoa's forging plants, with hydraulic press capacities up to 50,000 tons, provide on-the-nose deliveries.

Think of Alcoa® Forgings when strength and lightness are rigid design requirements. Producing a complete line of forgings, Alcoa forges more large and complex shapes than any other supplier. Aluminum Company of America, 919 Alcoa Building, Pittsburgh 19, Pennsylvania.

**The patterns shown in the illustration were produced in Alcoa's Research Laboratories as part of a study of grain flow developed by the dies used to forge the DC-8 wheel.*

Alcoa puts the metal where you want it—in castings, forgings, impacts, extrusions and screw machine parts.

ALCOA ALUMINUM

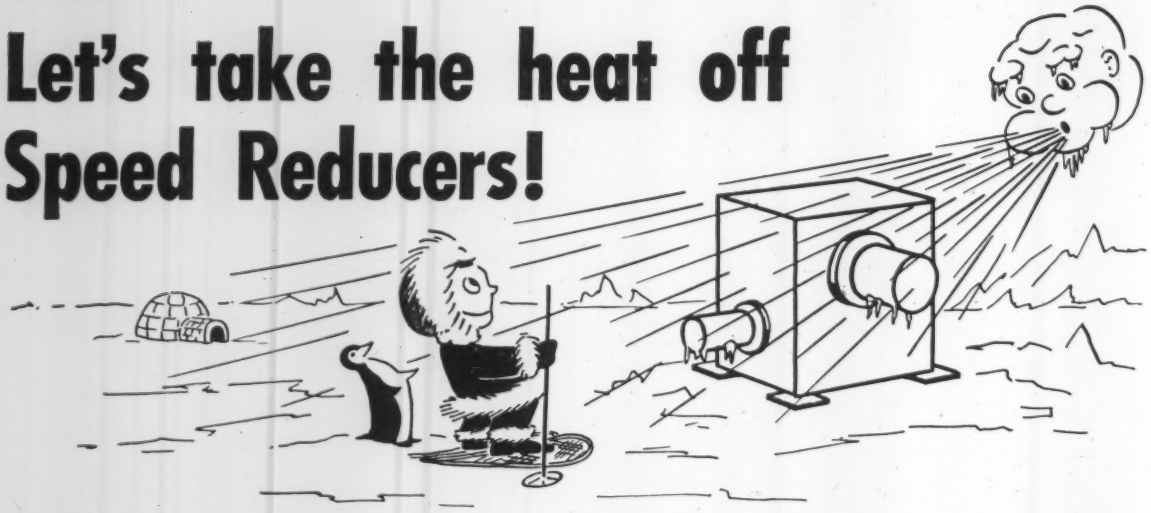
ALUMINUM COMPANY OF AMERICA

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

Your Guide to the Best in Aluminum Value

(Advertisement)

Let's take the heat off Speed Reducers!



A worm gear speed reducer is one of the toughest little customers in captivity. It reduces speeds day-in, day-out, with little complaint. While it works long and hard, it has limitations—set by ratio, center distance, RPM, mechanical and thermal HP ratings, etc. And, depending upon how precisely it was selected and fitted to the job requirements, it will do what it has to do.

But sometimes it's forced to play outside of its league. It must cope with job requirements that vary from here to there—normal 8 to 10 hour service without recurrent shock, the same length of service where there is some shock loading, continuous low-speed service and almost countless others. But the thing that really puts the pressure on reducers, the thing that's lurking in *every* set of job requirements—is h-e-a-t.

When you exceed the thermal capacity of a reducer for more than an hour or so, excessive temperature thins the lubricant resulting in wear; material, bearing and oil seal failures; etc. Of course, the proper lubricant will help but it can't cure the continuing problem of excessive heat.

So how can we lick this toughy? One way is to build the reducer housing oversize, big enough to radiate the heat away and keep temperatures down. But this type sticks out in aisles, louses up compact designs and barks shins. Then, we might try a smaller housing complete with fins on it to dissipate the heat. If this still doesn't work, another trick is to use a reducer with capacities and ratings a step above the ones we need. This is sending a man to do a boy's job. It's impractical, inefficient and costly. There *has* to be an easier, better, saner and cheaper way to do it. And there is!

In certain cases, where the size and type of reducer permits and where we can gain enough in thermal HP rating to keep heat generation in bounds, Cone-Drive Gears does it with fan-cooling.

What's that? Simple. Just add a fan to the worm shaft plus the necessary air shields, fan cover, etc., and presto!—heat is no longer a problem. The air shields direct the fan-pushed air over the fins on the lower portion of the reducer. The fins are shaped and spotted to guide the air stream where it is needed. Thermal HP ratings are boosted tremendously, as high as 147% above those of standard reducers in some cases! Those over-worked, over-heated reducers will now do the job you bought them to do.

Other advantages? They're here in abundance. The size of the reducer stays the same. All parts on a Cone-Drive fan-cooled reducer are 100% interchangeable with parts for standard reducers. Oil capacity is identical. Shields are quickly removed without disconnecting the reducer. (This is important where severe operating conditions make periodic cleaning necessary). The reducer can also be operated *without* fan-cooling just by taking off the fan and shields.

This simple addition to standard Cone-Drive HU speed reducers might be just your answer—might save you some money. Write for Cone-Drive's Bulletin CD-218. It will tell you all about the full line of Cone-Drive double-enveloping worm gear reducers as well as the fan-cooled kind. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

Circle 491 on Page 19

Circle 492 on Page 19→

A NEW ERA IN RELAY LIFE AND RELIABILITY!

A-B QUALITY

THEY MAY LOOK ALIKE, BUT

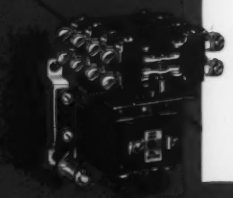
these new relays completely outmode the usual concepts of relay life and reliability.

For years the Allen-Bradley Bulletin 700 Type B and Type BX relays have been preferred for their long life and their consistent, trouble free operation. In having produced millions of these relays, we learned how to improve them. Thus, the new line of Type B and Type BX relays was designed to set a new level of performance standards.

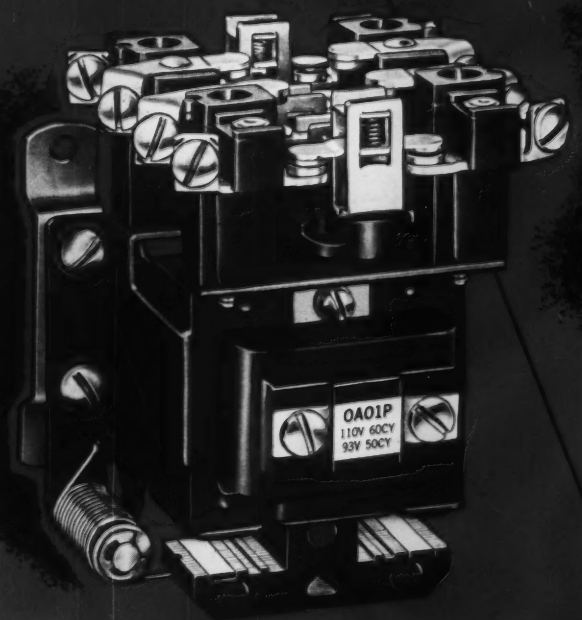
Turn the page and see the outstanding features of these new Bulletin 700 Type B and Type BX relays. For the same price, they offer you even greater value, greater reliability.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

old Bulletin 700
Type B-400 Relay
with 4 N.O. contacts



old Bulletin 700
Type BX-440 Relay



new Bulletin 700, Type B-220A
AC Control Relay with 2 N.O. and 2 N.C. contacts

new Bulletin 700, Type BX-440A
AC Control Relay can be wired for normally open or normally closed contacts

ALLEN-BRADLEY
Member of NEMA
QUALITY MOTOR CONTROL

7-59-MB

NEW BULLETIN 700 RELAYS

TYPE B AND TYPE BX

provide these improved features

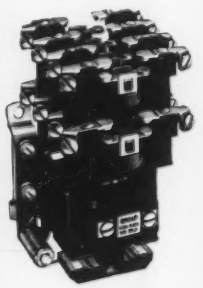
1. New mechanical design gives *at least* 5 times greater operating life.
2. New contact motion provides 10 times greater electrical reliability.
3. Compact construction—new relays are structurally improved with no change in size.
4. Complete interchangeability. Mounting dimensions of new relays have not been changed.
5. Rugged, high efficiency cast plastic coil. New, improved coil fits *all* Bulletin 700 relays.
6. New, stronger, movable contact crossbar—fits Bulletin 700 relays now in service.
7. Improved stationary contact blocks. These new blocks can also be used on present models of the Bulletin 700 relay.
8. Increased life and reliability—*no increase in cost.* These new, improved relays are priced the same as previous Allen-Bradley models.
9. The letter A is added to the Bulletin 700 relay type number merely to distinguish the new line.
10. These new relays are Allen-Bradley's "thank you" to our many customers who have bought millions of Bulletin 700 relays over the years.

A-B QUALITY

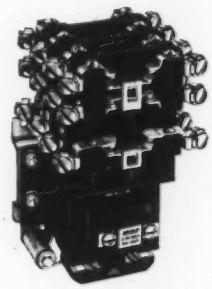
The old Bulletin 700 relay was first placed on the market some 25 years ago. Today, millions of these relays are in daily service—all over the world.

None of the old relay "values" have been lost in the new designs. Instead, these "values" have been greatly improved. The new relays feature a simplified, longer life, solenoid construction. The double break, silver alloy contacts are the same—always in perfect operating condition—without cleaning or filing. The operating coil has been greatly improved—it cannot be damaged by atmospheric conditions, no matter how severe.

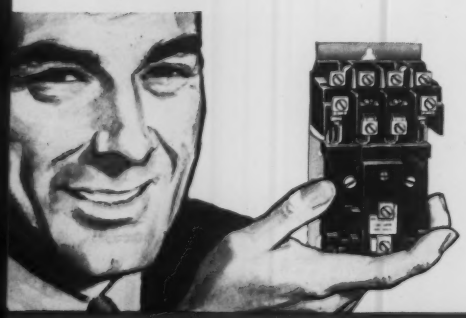
No one can deny the popularity of the older Bulletin 700 relays. The new relays—with their superior features—will be an even better answer for any and all relay applications.



TYPE B, GENERAL PURPOSE
Bulletin 700, 8-pole relay. Made with 8 N. O. and no N. C., or up to 4 N. O. and 4 N. C. contacts.



TYPE BX, UNIVERSAL
Bulletin 700, 8-pole relay with both N. O. and N. C. contacts. Changeover is made by reconnecting incoming lines.



HERE IS ANOTHER REMARKABLE ADDITION TO THE ALLEN-BRADLEY RELAY LINE

It's new . . . and it's different. This unusual Bulletin 700 convertible contact relay has contacts that can be changed from normally open to normally closed operation (or vice versa)—in just moments. A screwdriver is all it takes to do the job—no additional parts are needed. Like all A-B relays, it's good for millions of trouble free operations. Watch for announcement and full details of this new convertible relay soon!

ALLEN-BRADLEY

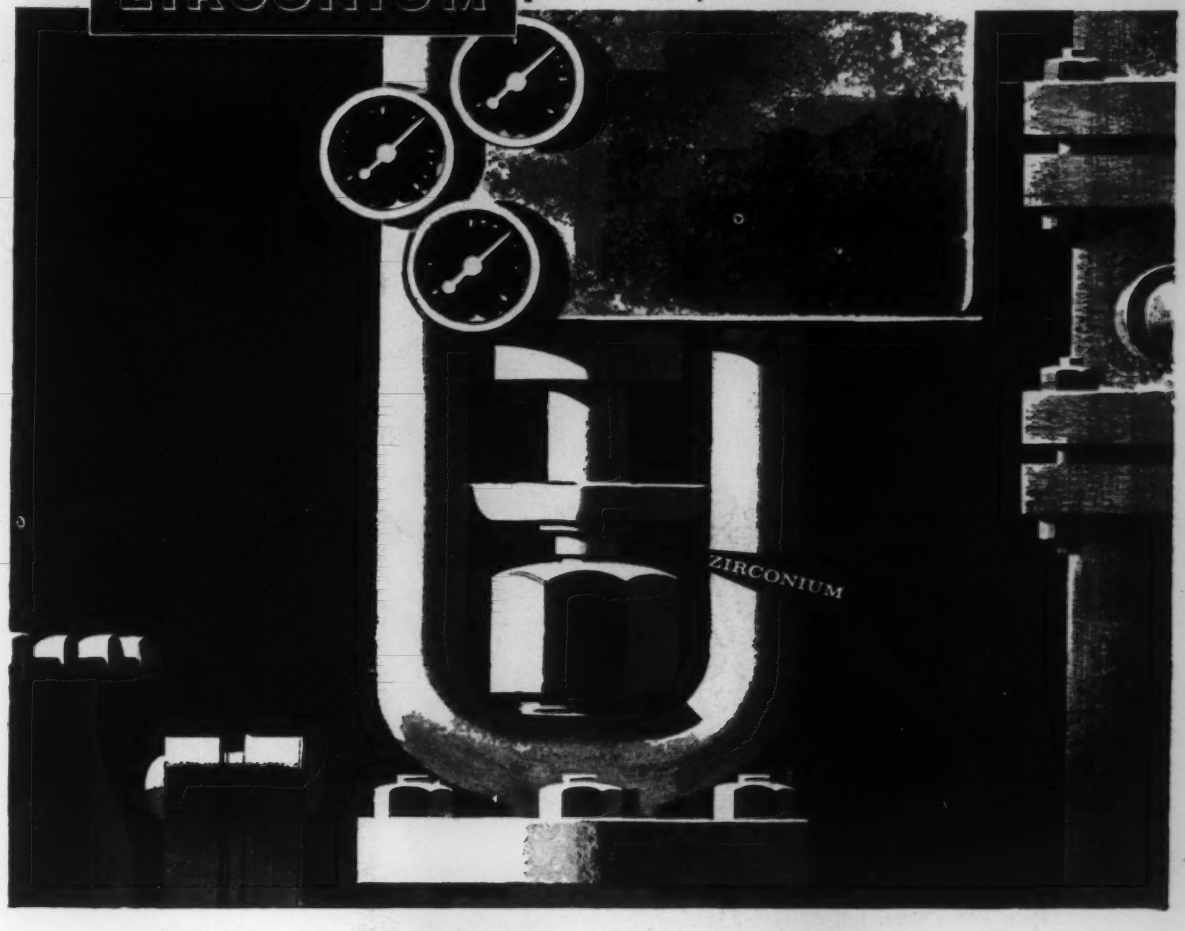
Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wisconsin
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

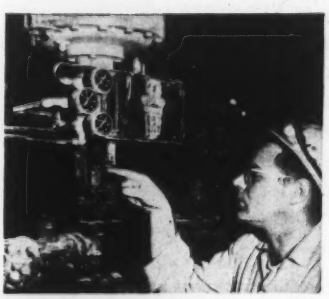
7-59-MB

QUALITY MOTOR CONTROL

ZIRCONIUM *proves ideal for corrosive acid service*



ZIRCONIUM VALVE STEMS OPERATING 27 MONTHS WITHOUT FAILURE



Zirconium-stemmed control valve, one of 40 still in operation after 27 months of acid service... at Mallory-Sharon sponge-reduction plant in Ashtabula, Ohio.

Here's a case history story we can vouch for personally. At the Mallory-Sharon sponge-reduction plant in Ashtabula, Ohio, 40 zirconium-stemmed control valves have been operating for over 27 months—*without a single stem failure!*

These valves are used in the toughest kind of corrosive service... hydrochloric and sulphuric acids in all concentrations ... raffinate... acidified hexone... solutions of ammonium thiocyanate and thiocyanic acid... and other solutions. Yet the valves have required very little maintenance or operator attention, have proved excellent in every way.

This proves an important point about zirconium. Even where its first cost is higher than for other materials, zirconium's extremely long service life and freedom from maintenance problems make it most economical for the long pull.

In many cases, it is the *only logical choice*—where lower-priced materials just do not stand up.

Why not take advantage of Mallory-Sharon's production and application know-how in zirconium? Write us about your corrosion problems... or request Technical Data Sheets on "Physical and Mechanical Properties of Zirconium".

MALLORY MS SHARON

MALLORY-SHARON METALS CORPORATION · NILES, OHIO

Integrated producer of Titanium · Zirconium · Special Metals

Circle 493 on Page 19

NEW...
from Skinner!

3-way, high-flow, solenoid valves for general industrial use

Main orifice sizes: full effective—⅜", ½", ¾" for ⅜", ½", ¾" NPT.

Standard operating pressures: 5 to 150 psi.

Media: oil, air, water, vegetable and petroleum oils, inert gases, kerosene, gasoline.

Types: normally open, normally closed and directional control in standard and explosion-proof construction.

These new, 3-way L3 Series valves, like all Skinner valves, are built to UL standards. Their bodies are made of forged naval brass and their internal parts are stainless steel and brass. Soft, synthetic inserts and seals provide bubbletight sealing. And a unique, Buna-N coated nylon diaphragm assembly assures long life. The valves are compact, light, and mount in any position, directly to the line. They are offered in a wide range of voltages and frequencies, with many electrical options and manual override.

Typical applications: air vises, chemical process equipment, presses, water treatment equipment, industrial machinery, packaging machinery, air and hydraulic cylinders, laundry machinery, etc.

Skinner solenoid valves are distributed nationally.

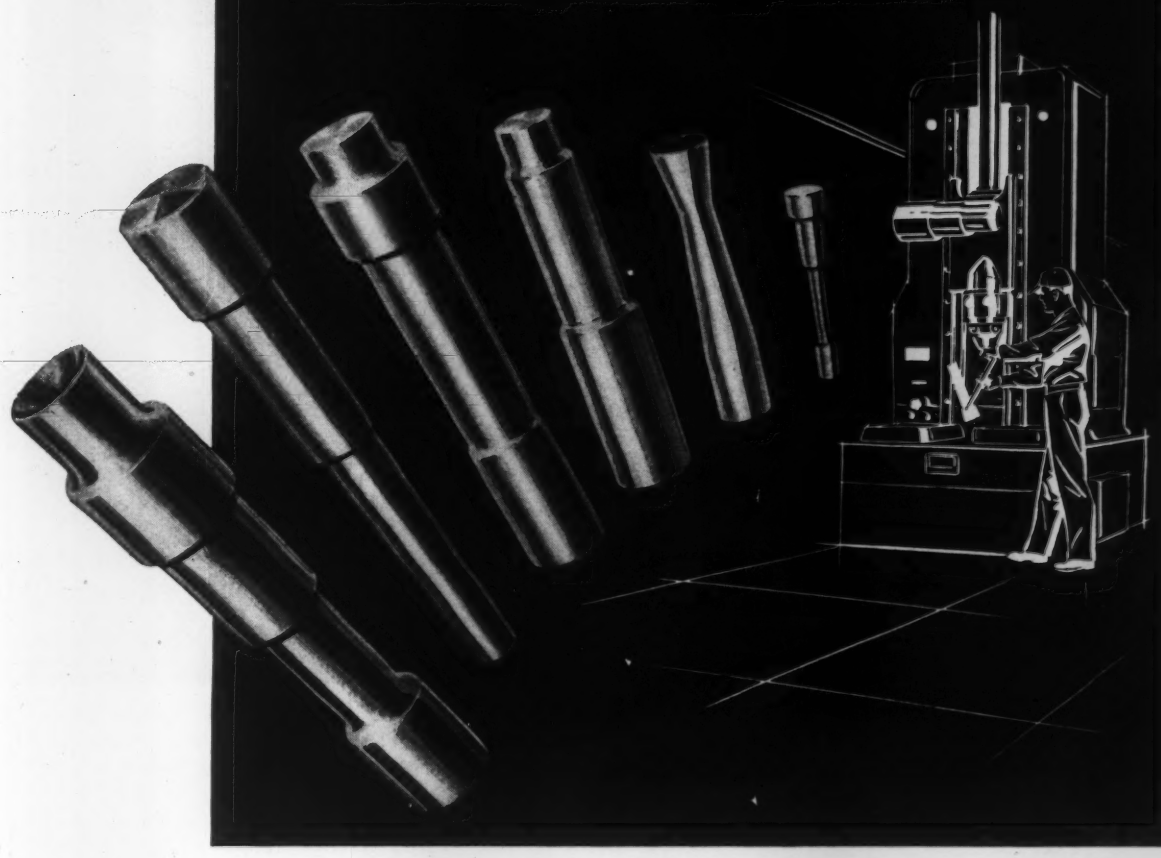
For complete information, contact a Skinner Representative listed in the Yellow Pages or write us at Dept. 429.

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY **THE SKINNER ELECTRIC VALVE DIVISION • NEW BRITAIN, CONNECTICUT**

Two big advantages!

CURMET Rotary Forging stops strength loss in premium alloys - cuts scrap loss up to 57%



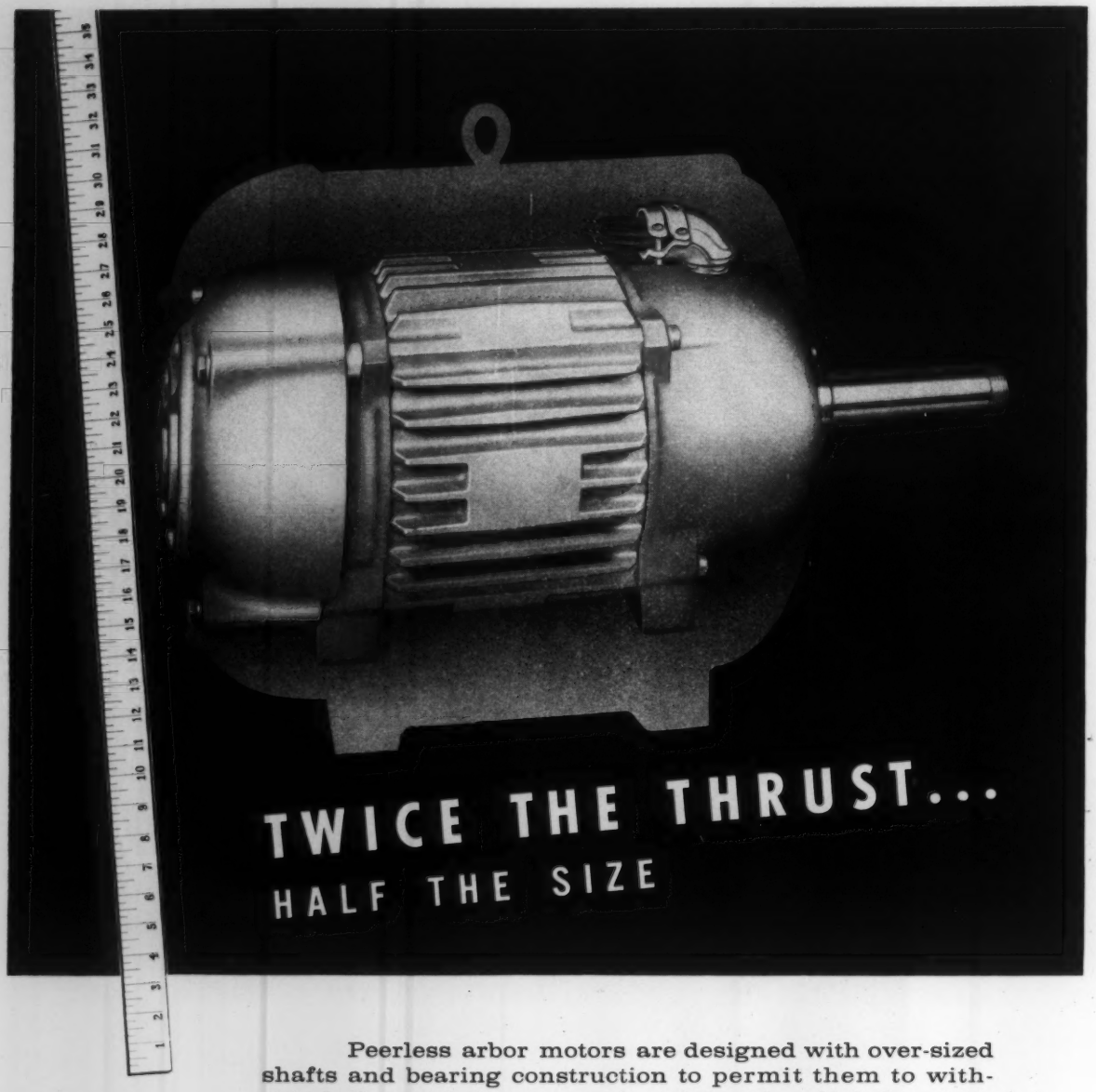
One prominent manufacturer saved 37½% in "K" Monel bar costs—found that the characteristics of the metal were vastly superior when it was CURMET rotary forged rather than machined. Other users report 25% . . . 13½% . . . 38% . . . even 57% saved in premium quality alloys—and the same improved properties in the finished product.

To get maximum strength from premium alloys, grain flow lines must remain intact. CURMET rotary forging stops strength loss because it eliminates cutting through these vital grain flow lines—keeps metal stamina up. In addition, this method minimizes waste of expensive metal stock by redistributing the metal instead of cutting it away. Scrap losses are always less.

When you require multi-diameter forgings measuring up to four inches and not over four feet in length—investigate CURMET rotary forging. The Curtiss-Wright engineer will be pleased to estimate *your* savings. And he will give you more information on the superior properties that the process achieves in metals.

Write us now for the completely new brochure on the CURMET rotary forging process.

CURTISS-WRIGHT CORPORATION 71 GRIDER STREET **METALS PROCESSING DIVISION** BUFFALO 15, NEW YORK



Peerless arbor motors are designed with over-sized shafts and bearing construction to permit them to withstand almost twice as much axial and radial thrust as comparable conventional units. They are compact — just half the size of standard motors of the same rating. Peerless builds them from 1 to 10 HP at 3450 RPM in cast, malleable or ductile iron frames. Peerless engineers will work with you to apply these units to your machine tools. If you have special requirements, Peerless may be able to shorten the required lead time by drawing on its files of comparable applications. We'll help you select or develop the one motor which powers your product best.

ELECTRIC MOTOR DIVISION

THE *Peerless Electric*® COMPANY

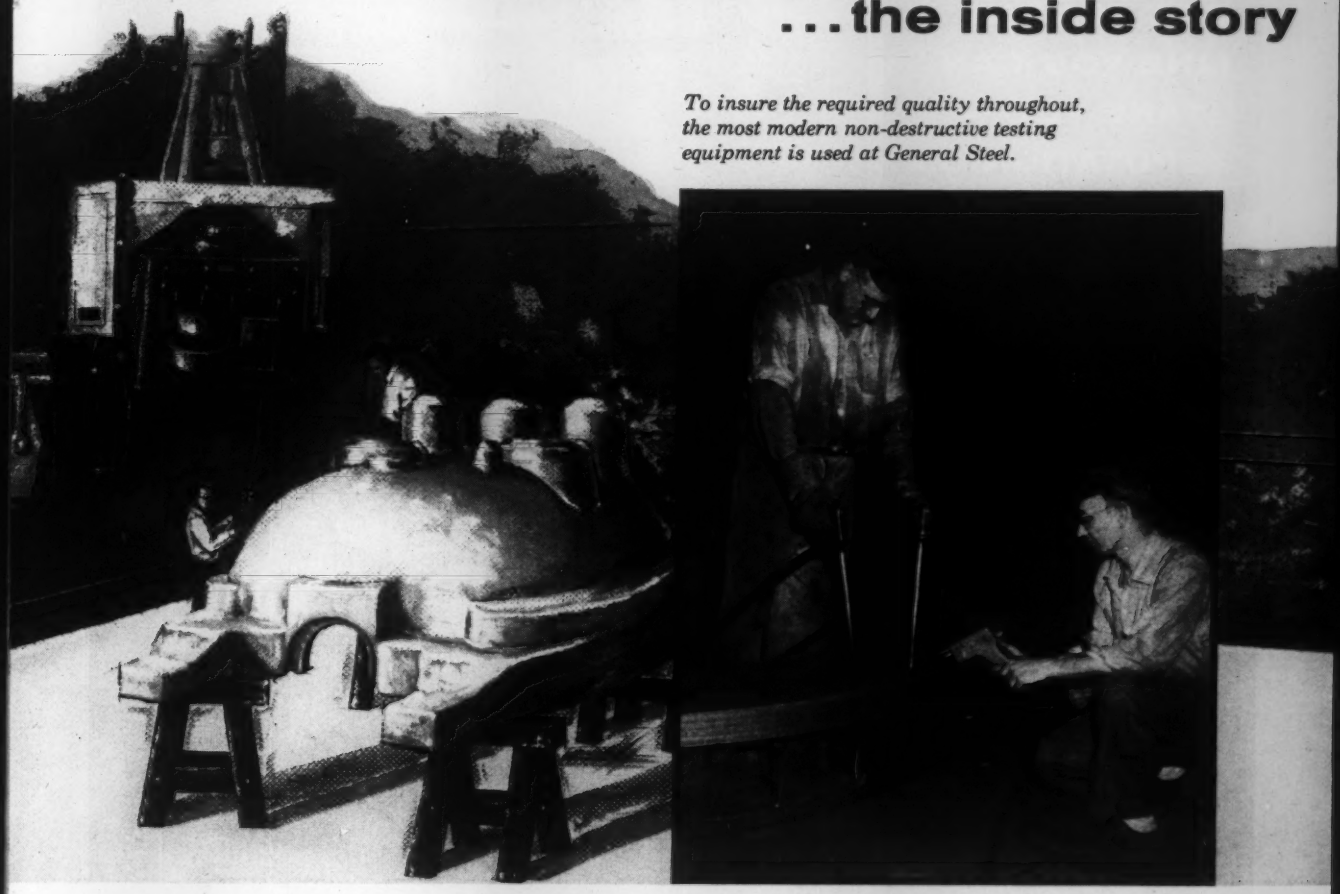
FANS · BLOWERS · MOTORS

1520 W. MARKET ST. · WARREN, OHIO

Circle 496 on Page 19

...where industrial progress is cast in steel

NON-DESTRUCTIVE TESTING ...the inside story



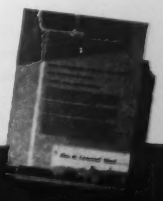
To insure the required quality throughout, the most modern non-destructive testing equipment is used at General Steel.

To meet rigid specifications for high temperature, high pressure and other applications requiring quality components, General Steel uses the most modern non-destructive testing equipment available. Testing for quality is performed by various methods depending on the type of structure.

Among the facilities available at General Steel are magnetic particle inspection units to check for invisible surface defects, and ultrasonic reflectoscope units for sonic testing of internal metal. Radiographic inspection of very heavy structures is done with 24-million volt Betatron units. Conventional X-ray equipment is used for smaller structures. Other methods of non-destructive testing are also available.

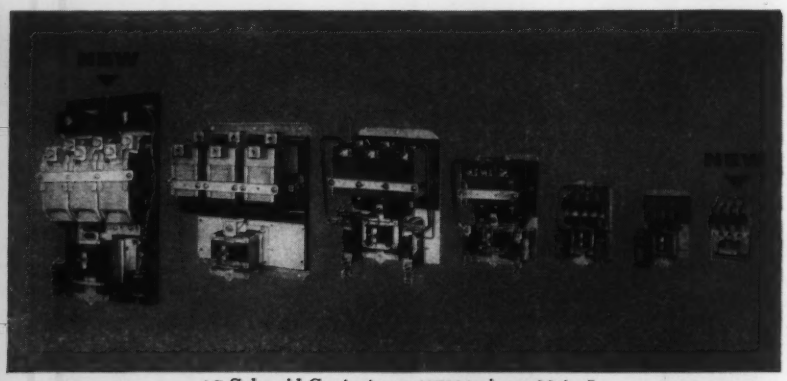
Profit from General Steel's wide experience in the design and production of high quality product components made of cast steel, cast-weld or composite structures. Let our staffs work with you in developing designs for optimum performance.

Write for folder **How General Steel Castings Can Improve Product Design and Performance.** General Steel Castings, Station 260 Granite City, Illinois



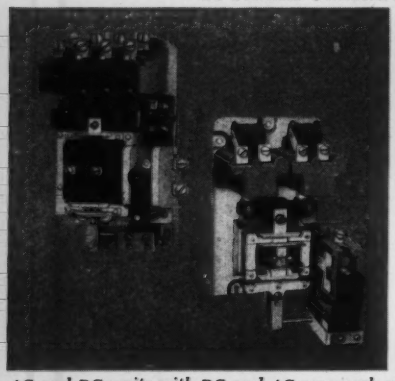
GENERAL STEEL CASTINGS

HERE'S A CONTROL COMPONENT LINE YOU CAN STAKE YOUR REPUTATION ON

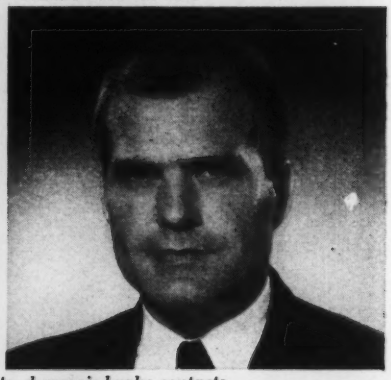


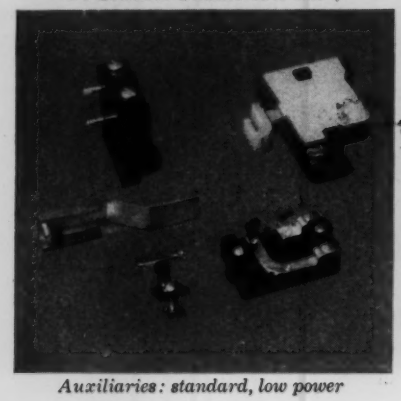
AC Solenoid Contactors • NEMA sizes: 00 to 5

DC Solenoid Contactors to size 4

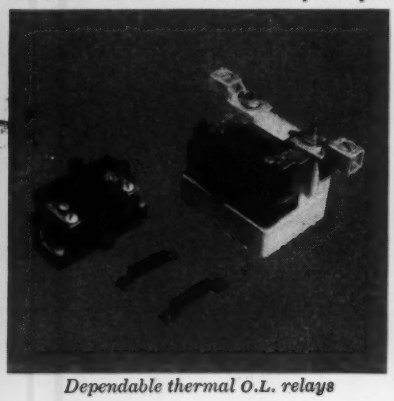


AC and DC units with DC and AC power plants, dynamic brake contacts

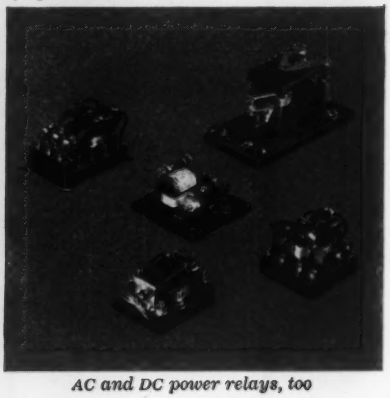




Auxiliaries: standard, low power



Dependable thermal O.L. relays



AC and DC power relays, too

It's completely versatile and designed for both standard and specialized controls

From the little Size 00's to the powerful Size 5 contactors you'll find maximum reliability built right in . . . whether your application is in motor control, resistive heating or lamp switching.

Meticulous attention to design features guarantees you top-notch performance . . . especially where hi-reliability is a "must." All AC and DC contactors for example, come equipped with simple, fast-acting, trouble-free solenoids. There are no complicated linkages or potentially troublesome pins or bearings . . . no adjustments needed either.

The main *and* auxiliary contacts are of the double break type designed for maximum reliability even where high in-rush currents are met. Contacts are accessible for inspection, too!

Other key contactor design features include: identical mounting centers for AC *and* DC; all units designed for front-of-board wiring *and* mounting; magnetic blowouts furnished above 25 amp. size on DC; fully accessible terminals make installation easy.

On your next control job, standard or special, specify W/L Control Components. Send for detailed Control Catalog: Ward Leonard Electric Co., 58 South St., Mount Vernon, N. Y. (In Canada: Ward Leonard of Canada, Ltd., Toronto.) 9.5

WARD LEONARD
ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

LIVE BETTER...*Electrically*

Result-Engineered Controls Since 1892

RESISTORS | RHEOSTATS | RELAYS | CONTROLS | DIMMERS

Whatever your design problem there is a

Faultless Caster

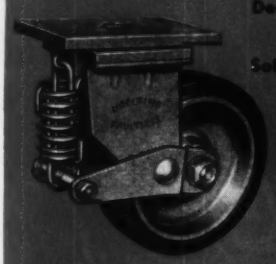
to solve it!

Design Problem:
Shimmyless, Quiet-running Caster for Hospital Carts and Stretchers

Solution:
Series 2400 Medium Duty Swivel Stem Truck Caster. Hardened ball bearings running in 2 raceways machined to closely held tolerances. Precision adjustment of swivel assembly elimates troublesome wobbling of ordinary kind. 5", 8" or 10" dia. wheels for smooth, noiseless rolling.

Design Problem:
V-Grooved Wheel to Follow Angle Iron Tracks

Solution:
Light, medium and heavy duty casters are available with 4" to 10" V-Grooved Wheels to carry loads from 325 lbs. to 15,000 lbs. along unobstructed tracks. Save floor surfaces, eliminate noise and vibration. V-Grooved Wheels have flat outer treads for use on floors.

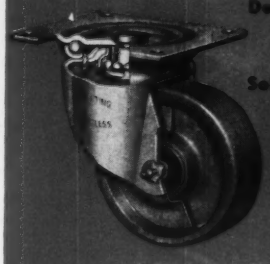


Design Problem:
Cushion Action Caster for Level Ride over Irregular Floors

Solution:
Series SH300 Spring Action Swivel Plate Truck Caster eliminates bounce. Caster maintains continual floor contact. Durable, long-lasting spring and draw bars, on center line of wheel, absorb shock and lengthen life of ball bearings, raceways and wheels.

Design Problem:
Scaffold and Platform Caster that Double Locks against Movement

Solution:
Series C900 Scaffold Caster has Brake that simultaneously locks both swivel and wheel. Scaffold will not creep. Foot or hand operated brake lever locks in up position . . . releases in down position. Large diameter wheel for smooth rolling over ordinary obstacles.



Design Problem:
Sealed Caster Bearings for Use in Extreme Temperatures or Moisture-laden Air

Solution:
Series 900 GS Swivel Plate Truck Caster has built-in protective grease seals around main load, thrust and wheel bearings. Exclude water, chemicals, dirt. Prevent grease leaking to floor, assure easy maintenance, low upkeep.

Design Problem:
Exciting, All-New Caster Concept To Enhance Your New Furniture Line

Solution:
Royal-Roll, the "King of Casters" combines unique styling and time-tested furniture caster engineering. Double ball bearing swivel, non-marking wheel and hooded horn. Spherical black wheel with bright nickel or brass horn. Stems for wood, tubular metal and cast legs.

For FREE Condensed Catalog, or more information on specific Casters, fill out coupon today. Or contact your nearby Faultless Distributor who is listed in classified directory under Faultless heading.

Tell me more about:

- ☐ Series 2400
- ☐ V-Grooved Wheel
- ☐ Series SH300
- ☐ Series C900
- ☐ Series 900 GS
- ☐ Royal Roll

Faultless Caster Corporation
Evansville 7, Indiana

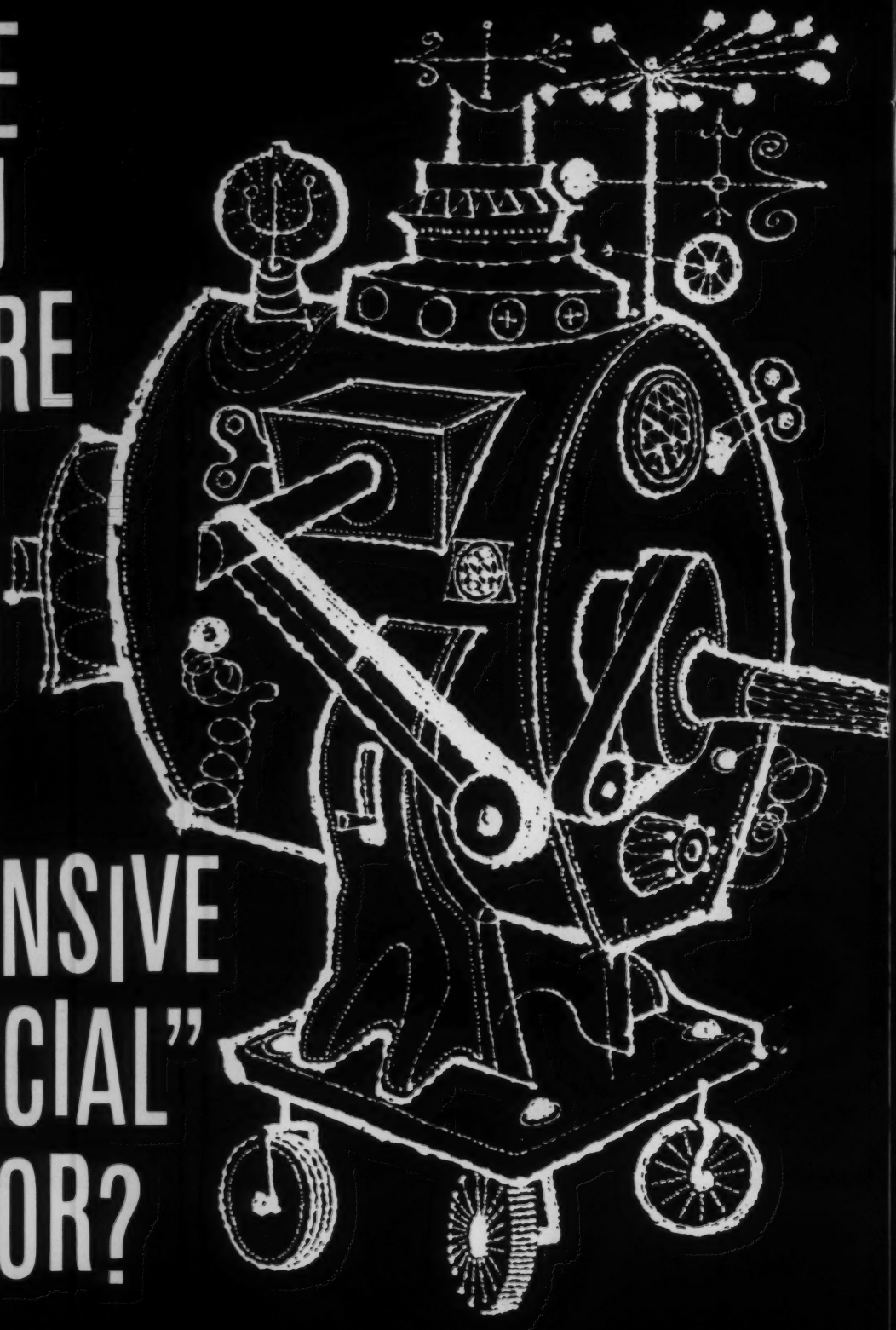
Name_____

Title_____

Company_____

City_____ State_____

ARE YOU SURE YOU NEED AN EXPENSIVE "SPECIAL" MOTOR?



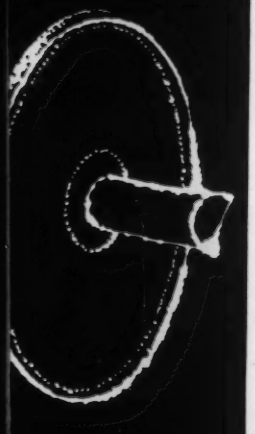
INEXPENSIVE WESTINGHOUSE STANDARD MOTORS HAVE BEEN DOING "SPECIAL" JOBS FOR YEARS!

Sometimes you have to use a "special" motor. But *not usually!*

Even though your application is a "special" one, the chances are excellent that you can apply a *Westinghouse standard* fhp motor without a loss in efficiency, appearance or output—and at a much lower cost.

Bear in mind, too, that Westinghouse engineers build the *Westinghouse standard* motor to the very top of NEMA specifications—your assurance of super-standard performance!

Here are some other concrete examples of the advantages of using *Westinghouse standard* motors:



LOWER PRICE! . . . of course

LESS ASSEMBLY TIME! . . . on your production line.

NO REPLACEMENT PROBLEMS! . . . for your customers.

REPAIR FACILITIES! . . . on almost every corner.

SURE DELIVERIES! . . . right from the shelf.

LOWER PRICE! . . . we said that, but it bears repeating.

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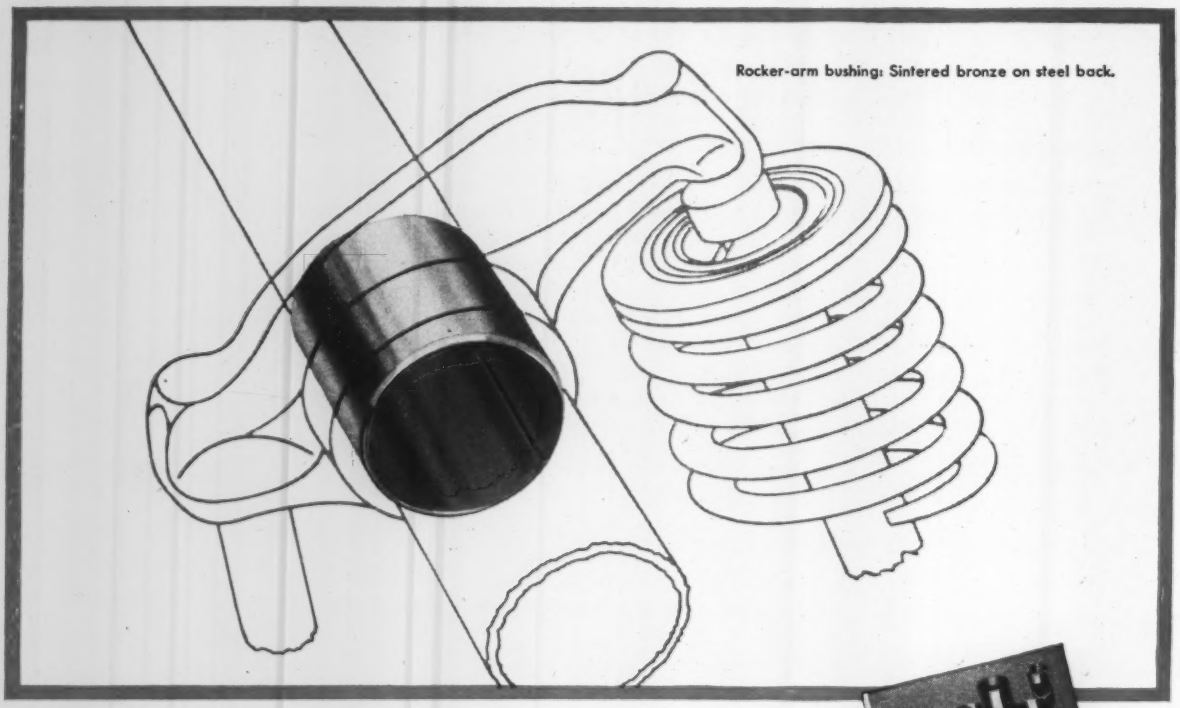

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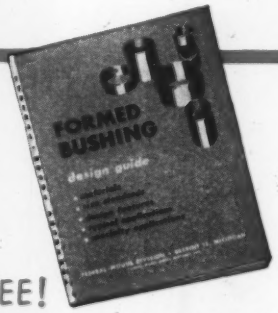

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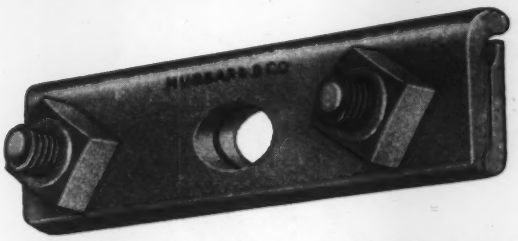

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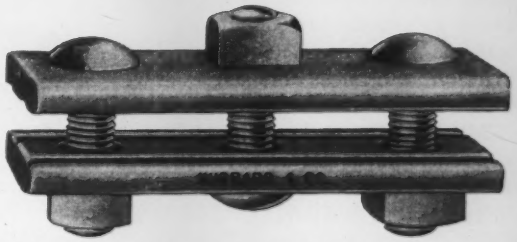

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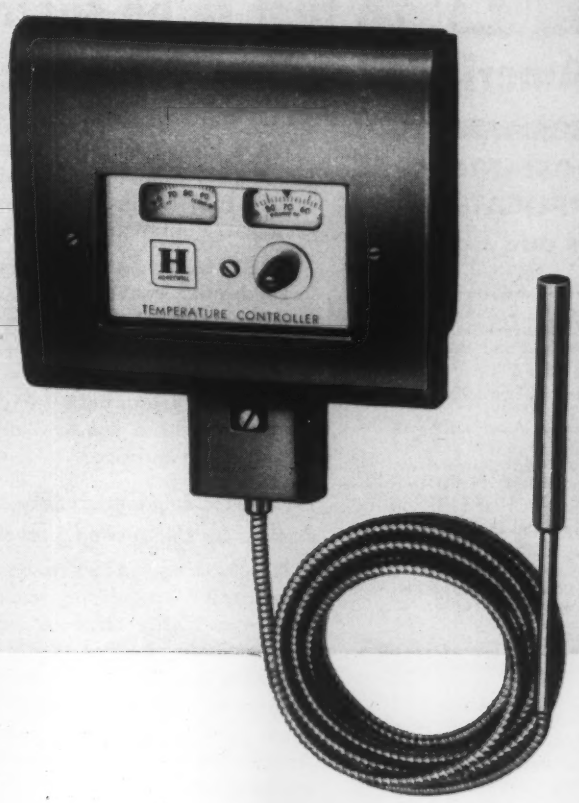

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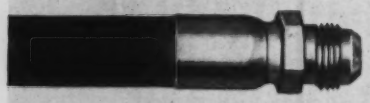

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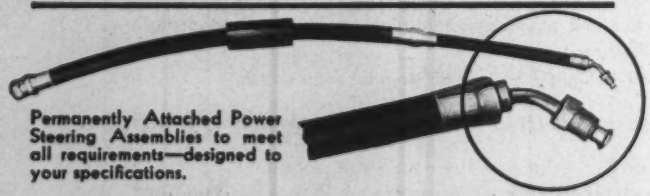

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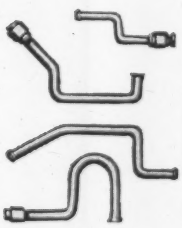

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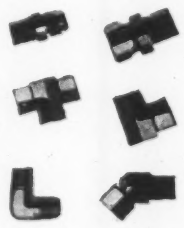

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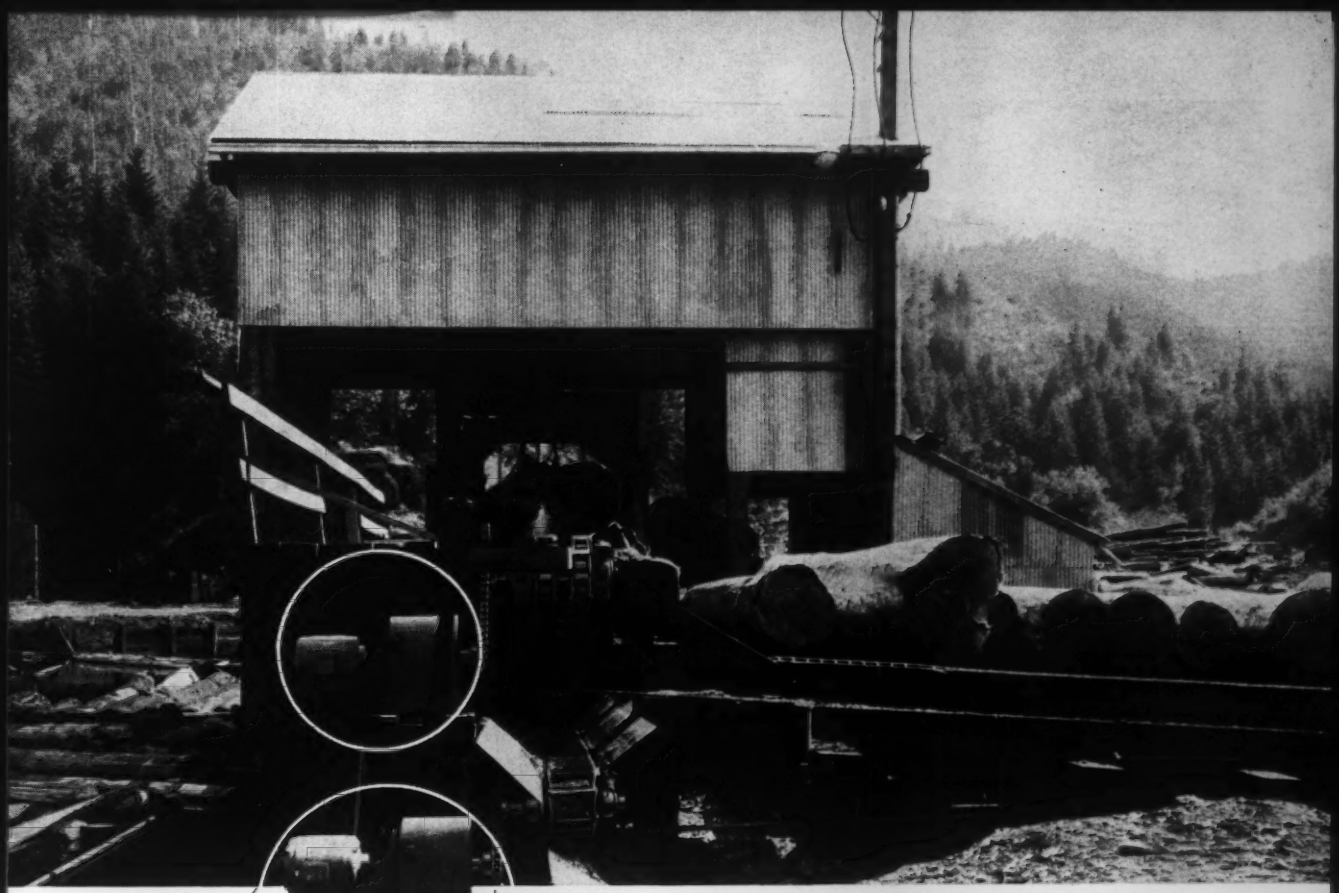

FALK Motoreducers driving log conveyor and refuse conveyor at the modern mill of The Bohemia Lumber Company, Culp Creek, Oregon.

FALK *all-steel* Motoreducers give you longer service life

Whether your load conditions are normal or heavy, the extra rigidity of all-steel construction (more than twice that of cast iron) maintains better alignment of revolving elements under load...a vital factor in prolonging the service life of gears and bearings.

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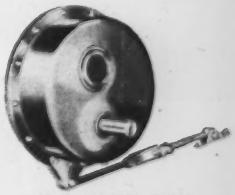

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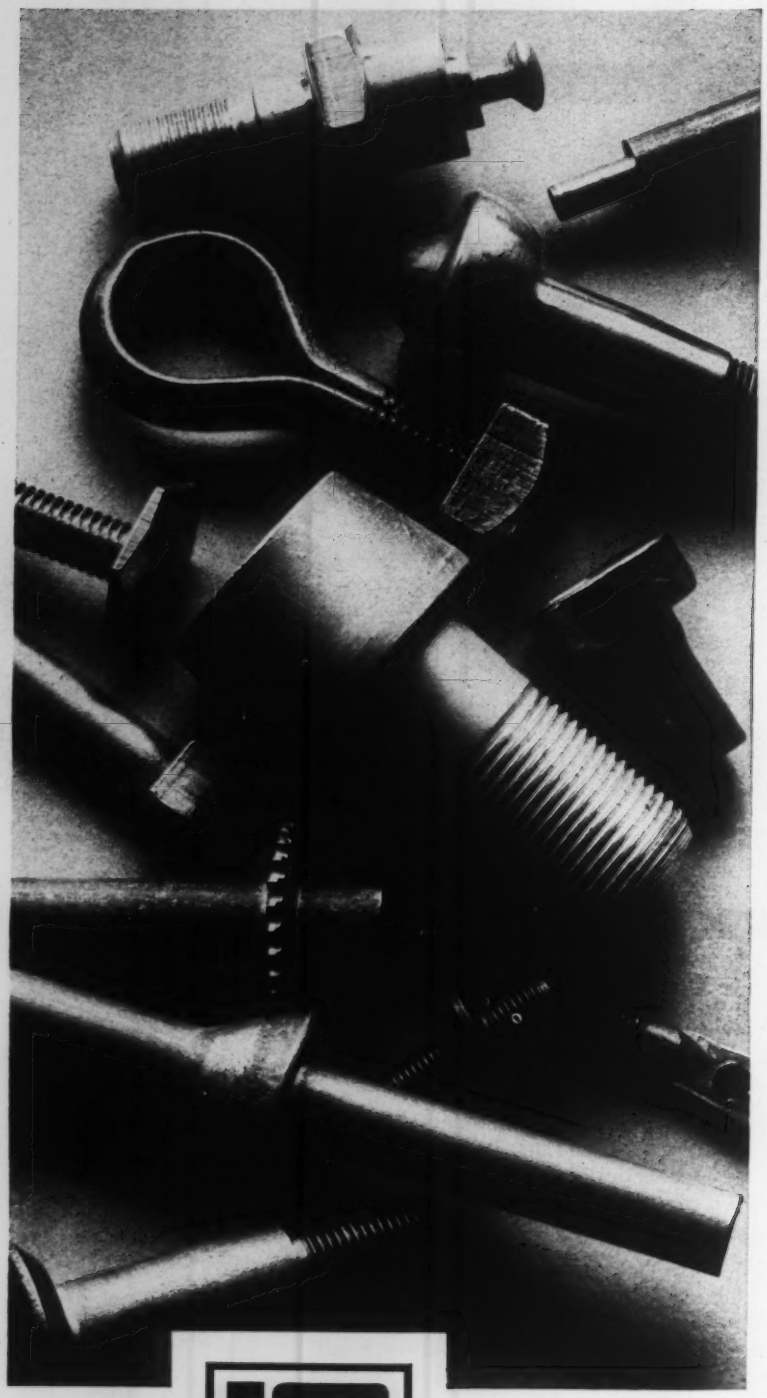

A bolt is a bolt... or is it?

At L & S, "bolts" often take on strange shapes...such as those shown here. Why? Because customers need them that way...to solve a specific fastening problem. Strange thing, though—what may seem very "special" to you may require only a slight modification of something we've already made. We have the know-how *and* the equipment to design it, produce it, economically! Send us your prints or problems.

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Circle 506 on Page 19

IRON AGE DESIGN
September 17, 1959

Function or Fad?

SUSPICION always haunts the guilty mind; the thief doth fear each bush an officer." Since Shakespeare put these words in Gloucester's mouth, the nature of the mind hasn't changed. How else can you account for Mr. Krushchev's remarkable outburst and running debate with Mr. Nixon, so obviously triggered by the "Captive Nations Week" resolution? The intensity of the reaction reveals with unmistakable clarity the sensitivity of the Soviet mind.

So long as that mind continues to be obsessed by fear and guilt, its owners will see a distorted vision of the rest of the world. But exchanges of exhibits and delegations, and visits of top leaders, offer a hope that minds long closed by suspicion, ignorance, and prejudice can be opened.

If that ever happens, the diversion of talent and energy now going into armaments could bring about competition in peaceful scientific and technical achievement the like of which the world has never seen. Would we be ready for it?

The Russians are a practical people. They also appear to enjoy working. In peaceful competition, that combination could make good Mr. Krushchev's boast "We will bury you," if we permit them.

A little mind-opening on our side wouldn't hurt. For instance, for some time most of our automobile manufacturers have been regimented and obsessed by the high-styled, big-car concept. On the other hand, according to Norman Cousins in the *Saturday Review*, the Russian *Volga* provides dependable transportation in genuine comfort—in some respects more so than our over-styled luxury vehicles.

There's evidence of similar obsessions in other areas of design engineering here—a trend away from basic functional simplicty and a preoccupation with fads. We call it "gracious living"; the Russians call it "decadence."

Colin Carmichael
EDITOR

Refinements in dimensioning concepts help engineers say exactly what they mean . . .

where drafting standards leave off

It's common practice these days for engineering drawings to be used in companies outside the companies which originate them. That's why it's all the more important for originators to describe finished parts and assemblies completely and intelligibly. That done, drawing users must interpret descriptions accurately. Current drafting standards help a lot, and this article gives do's and don'ts for further improvement.

REGINALD E. STANLEY
Checking Supervisor
Sundstrand Aviation
Div. of Sundstrand Corp.
Rockford, Illinois

LATELY, many drawing specifications for the geometry of finished parts have been shortened to concise phrases or symbols. Existing standards—industrial, commercial, and military—attempt to define these terms. Individual companies adapt the national standards to their own purposes. Despite these efforts, the precise meanings of terms are still widely misunderstood. Discrepancies between interpretations seem due to confusion between the intentions of remarks and the ways they are expressed.

Omissions: An obvious fault, and perhaps the easiest to correct, is the omission of information. Common cases are shown in Fig. 1.

Tolerances and concentricities are two other requirements often omitted. Since tolerances are often repetitive, general tolerance blocks on drawings or in shop practice standards are popular. Both are obvious ways to avoid numerous drawing notes, but there is a temptation to use them blindly. On the other hand, by completely avoiding tolerance callouts, control of the product becomes a matter of interpretation and opinion.

Geometry Callouts: Aspects of tolerancing which are still open largely to judgment involve some of the most critical tolerancing on drawings. The most

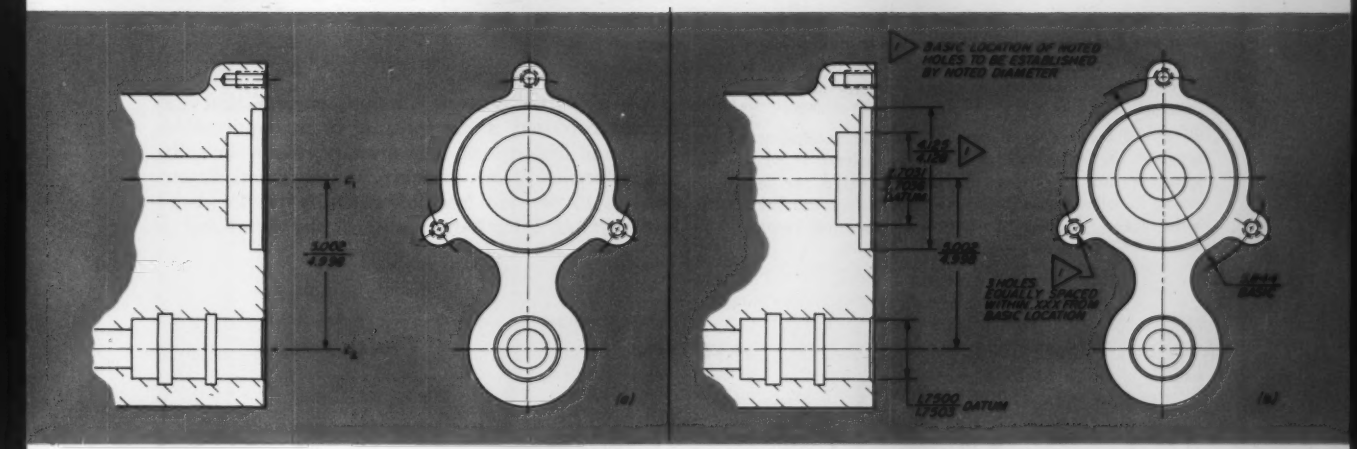


Fig. 1—Datum labels put first things first.

Both centerlines c_1 and c_2 represent the nominal centers of several diameters, but it is impossible to determine which particular pair of diameters is spaced by the given dimensions. Usually, the center distance is more functional to one pair than all others. This pair must be labeled consistently in order to be interpreted consistently. Simply apply the word DATUM to each of the two diameters, as in Example *b*.

Another omission concerns the tapped holes around centerline c_1. These holes comprise a basic system around the nominal centerpoint of several diameters.

One diameter must be chosen as the logical starting point of the tapped-hole pattern. This diameter must be specified on engineering drawings, not left to manufacturing or inspection departments.

In this example, the center of the diameter (4.125/4.128), which is functional for the tapped holes, is not the center of one of the diameters (2.7031/2.7036 DATUM) selected for centerline spacing. The center of the hole pattern is distinguished by a note, BASIC LOCATION OF NOTED HOLES TO BE ESTABLISHED BY NOTED DIAMETER. If one diameter served both purposes, DATUM would suffice.

often misinterpreted and confused area is geometry callout. No standard in existence precisely states when geometry requirements are permitted to extend beyond the sizing tolerance or when the geometry must be contained within the sizing band.

The standards ASA Y14-5-1957, SAE Dimensioning Standard, and MIL-STD-8A all give definitions of geometry and illustrated examples. But they make no attempt to specify what types of geometry actually summate the sizing limits and what types do not. They do indicate that when no geometry is specified, the size limits contain all permissible forms of geometry.

When geometry callout is restricted to one surface, with no relation to a datum surface, it is interpreted as a condition always within the tolerance limits derived from size dimensions, Fig. 2.

It would seem that a geometry requirement dealing with a surface characteristic only, and not involving location of the surface, indicates that such a geometry band must be contained within the sizing band. This is true.

Conversely, it would seem that geometry requirements which involve location of a surface as a datum would indicate that a geometric tolerance need not be contained within the sizing band. This is not true.

These aspects of geometry requirements are illustrated in Fig. 3.

This thinking gives engineering a means to express precisely its intentions in sizing and geometry. General rules are:

1. When a geometric requirement is concerned with only one surface, a pure surface characteristic, the tolerance on the surface must be contained within the sizing band of the surface.
2. When a geometric requirement involves more than one surface, and a sizing dimension is violated by extending the geometry band beyond the sizing band,

the geometric tolerance must be contained within the sizing band of the surfaces.

3. When a geometric requirement involves more than one surface, and a sizing dimension is not violated by extending the geometry band beyond the sizing band, the geometric tolerance need not be contained in the sizing band.

When this constant interpretation is established, two other points become apparent:

1. A geometric tolerance contained within a sizing band does not make sense if the geometry tolerance is larger than the original sizing tolerance. This condition is only realistic when sizing and geometry are independent.
2. Since the concept of maximum-material condition is roughly the extension of geometry tolerance when some portion of sizing tolerance is saved, or vice versa, it follows that MMC extension does not make sense when applied to geometry contained within sizing. MMC is based on the summation of two values (geometry and size). When there is no summation, there is no saving and, consequently, no functional MMC consideration.

Unfortunately, the existing standards don't mention the fact that if geometry is better than the maximum limit specified, the feature size may increase proportionately. In case an example does not have geometry and sizing as independent values, there can be no extension of tolerance for either sizing or geometry.

Assembly Tolerances: Another concept that has become confused is the splitting of fit requirements into detail dimensions. The primary reason for splitting tolerance of an assembly fit into detail dimensions is to provide interchangeability at the detail level. When interchangeability of the detail part is

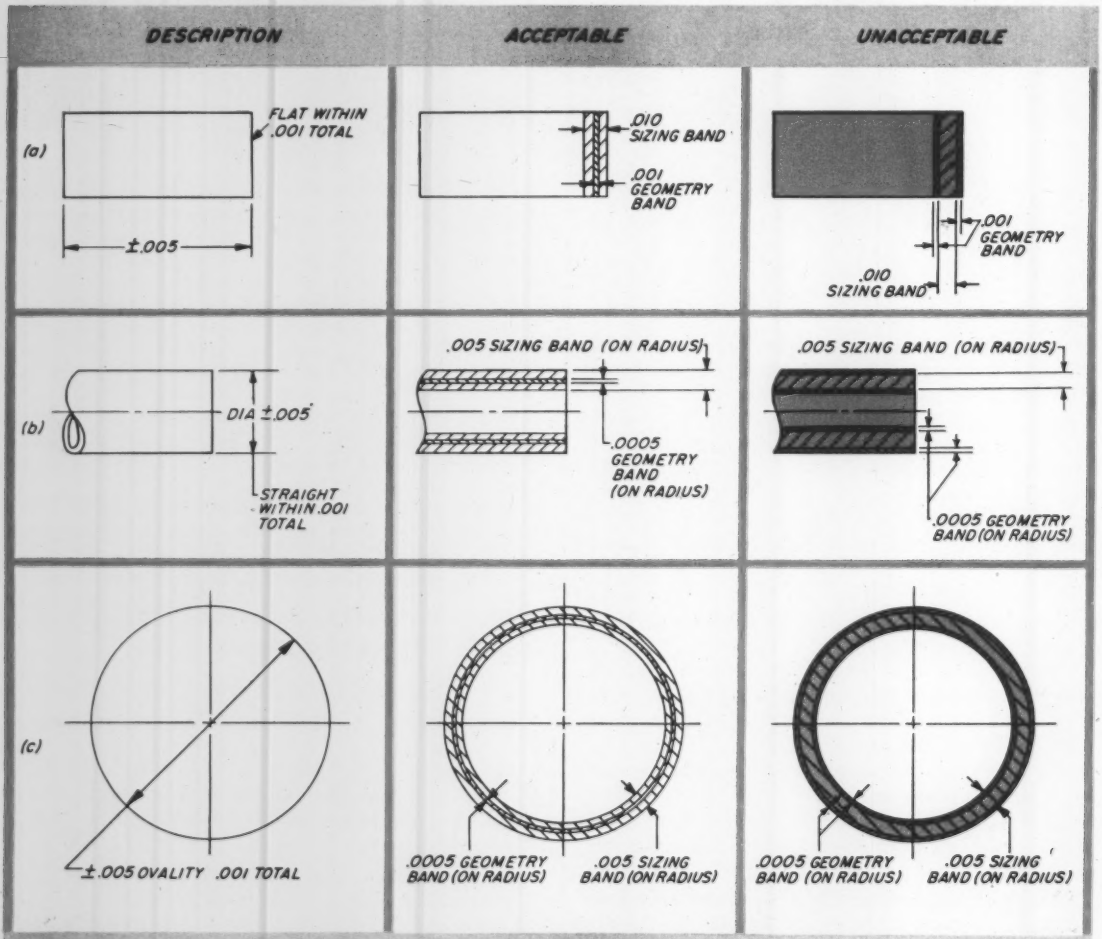


Fig. 2—Where there is no datum feature, geometry dimensions must not allow finished parts to exceed sizing dimensions.

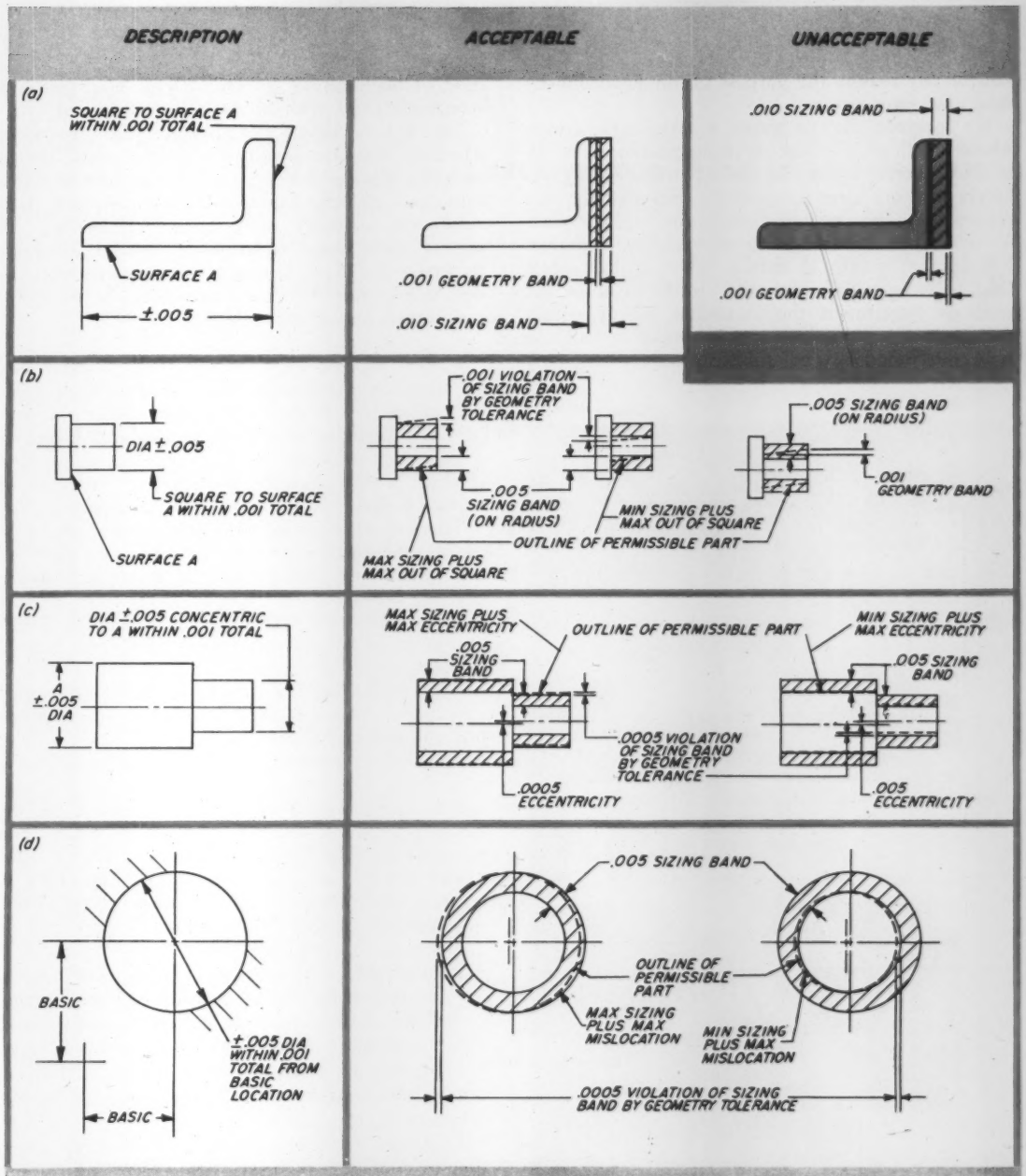


Fig. 3—Where there are one or more datum features, geometry dimensions may allow parts to exceed certain sizing dimensions.

Example *a* shows two flat surfaces with a squareness requirement, and Example *b* shows a cylindrical surface with a squareness requirement. Both illustrations involve a datum surface.

In Example *a*, a check on the sizing dimension proves that whatever the geometry, it is within the sizing band. Extending the geometry tolerance beyond the limits of sizing violates the sizing dimension. It is therefore logical to interpret the geometry of Example *a* as contained within the sizing band.

On the other hand, a sizing check on the diameter in Example *b* gives no indication of its squareness to surface *A*. Therefore, it would be logical to say that the squareness requirement may violate the sizing band as shown in the acceptable versions of *b*.

The same reasoning gives the acceptable interpretation of every geometric characteristic. See Examples *c* and *d* for concentricity and hole location.

lost for any reason, the purpose of the detail dimension no longer exists.

For instance, Fig. 4*a* shows a conceivable design where a split of tolerance serves its purpose. Fig. 4*b* is an example where the detail dimensioning no longer provides interchangeability, but actually represents only one possible combination of dimensions of an infinite number, none of which will recover the noninterchange of details which is lost when brazing is required. The only system to allow the methods department the maximum leeway within the engineering requirements is simply to call out only the functional requirements at the assembly level. Dimensioning at the detail level restricts acceptable parts with no real purpose served.

Fig. 4 is a simple example of what can occur wherever interchangeability is lost through design decision. Besides brazing, some of the factors which cause loss of interchangeability are: Selection, machining in assembly, and pinning in assembly. In any of these cases, it would always be advisable to screen the detail drawing to make sure that the description asks for true engineering requirements rather than unnecessary restriction.

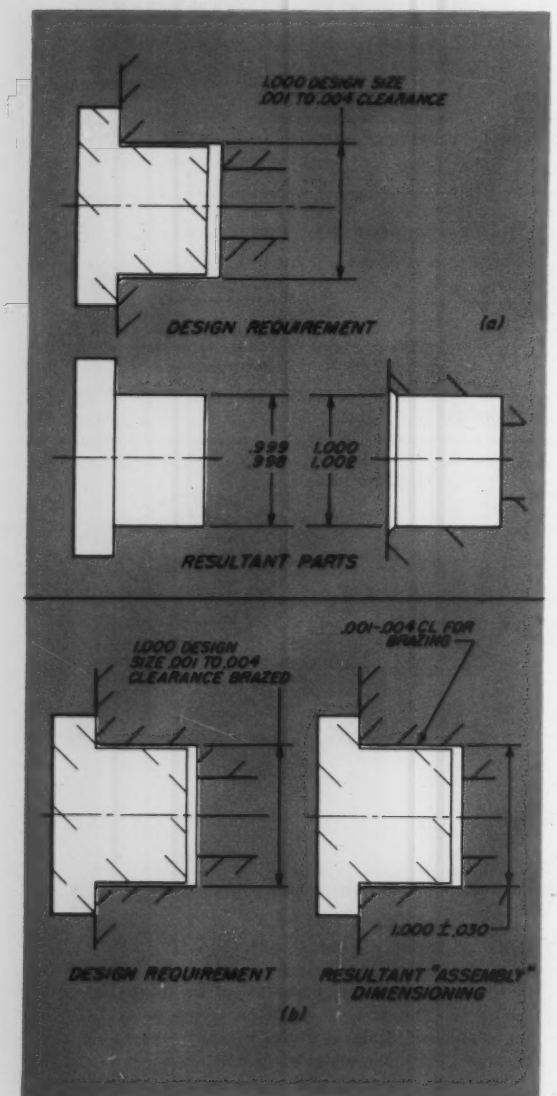


Fig. 4—In *a*, split tolerances assure a fit in finished parts. But if fit is disturbed, as by brazing *b*, tolerance splitting serves no purpose.

Purpose of Drawings: Beyond detailed ambiguities on engineering drawings, there is often evidence of a fundamental difference in concept as to the purpose of drawings. Most current standards define an engineering drawing as a description of an end product which satisfies engineering requirements based on performance of the end product.

There continue to be descriptions based on method of manufacture, tooling, or inspection that are not justified by functional requirements. Knowledge of capabilities of tools or gages will give the minimum practical limits within which the drawing must be for known manufacture and gaging, at least within a company's own facilities. But it will never disclose the functional limits that a part may have. This can only be done by investigation into the end use of the part.

More often than not, a description derived from a methods approach limits manufacturing and inspection departments more than necessary. In the majority of cases, functional limits are wider than practical manufacturing capabilities. Even in cases where this is not true, it would be impossible to increase true functional limits because current practical methods define higher limits.

Responsibilities for Drawing Details: Distinguishing the responsibilities of drafting and engineering is difficult. Failure to do so has led to confusion in many companies. Reasonable assignments are:

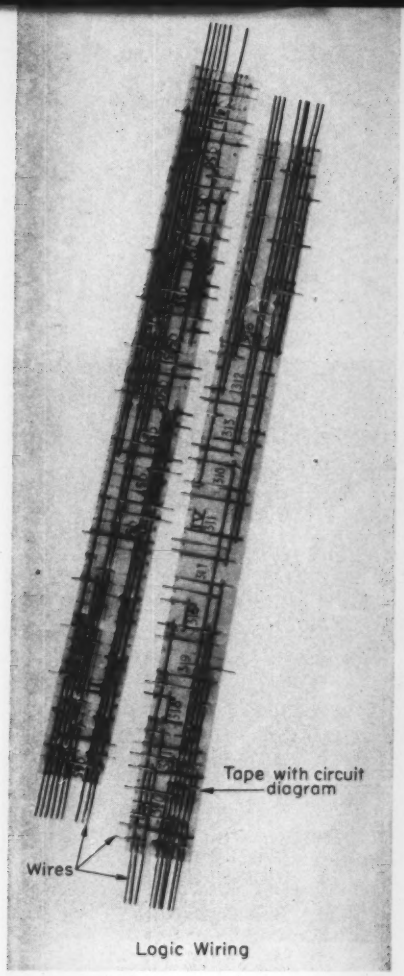
Engineering: 1. Basic design size. 2. Arbitrary dimensional requirements. 3. Necessary fits beyond fittability.

Drafting: 1. Splitting tolerances on detail drawings to guarantee necessary fits. 2. Proving fittability of parts. 3. Expressing all requirements in accordance with drafting practice.

Arrows Point Wrong Way

In "RF Heat Tins Wire Strand Before Insulation Is Stripped," Page 134, July 9 issue, the arrows indicating wire travel should point in the opposite direction. The wire stripper is the machine at the right, and the machine at the left is an automatic wire prefeed, both manufactured by Eubanks Engineering Co., Pasadena, Calif.

scanning the field for *ideas*

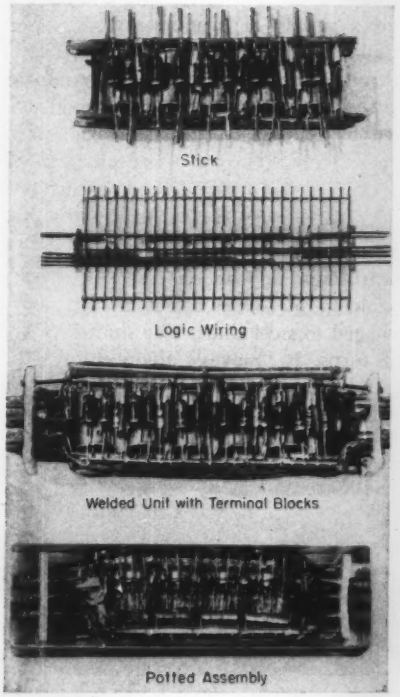


Logic Wiring

"Logic wiring" welded to interconnected subassemblies, increases component density in packaged electronic modules. The module construction is made of four basic elements: Stick, logic wiring, terminations, and potting. The stick consists of a number of subassemblies, which are welded together into a single assembly. Subassemblies are made by placing the components into jigs and welding the leads, as predetermined by the circuit diagram, to a nickel bus. Busses which connect symmetrical components of each circuit are clipped and removed, leaving the necessary connections to each individual circuit. The common input busses are left intact and brought out to terminal pins.

The logic wiring consists of two layers of nickel wires at right angles to each other, insulated by a plastic tape. On the plastic tape is printed the interconnecting circuit diagram, and holes are punched where a lateral wire welds to a longitudinal wire. After welding, all unnecessary connections are cut and removed.

The top and bottom logic wiring frames are assembled to the stick by welding all the individual circuit inputs and outputs to their respective positions on the logic wiring frame. Terminal blocks are then welded to the module, and the unit is potted. Logic wiring principle employed in component packaging technique developed by Raytheon Mfg. Co., Industrial Tube Div., Newton, Mass.

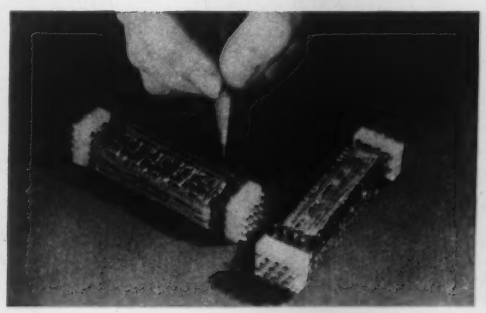


Stick

Logic Wiring

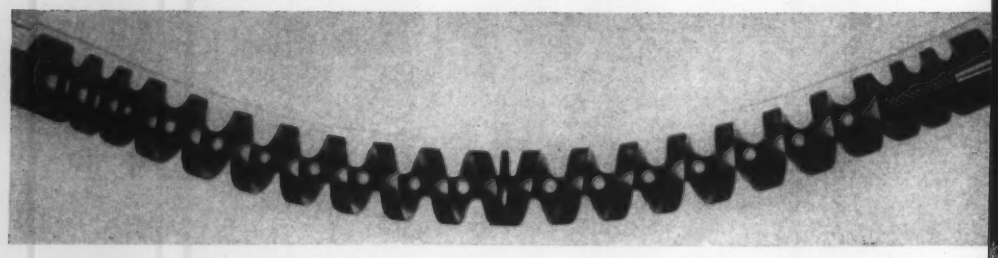
Welded Unit with Terminal Blocks

Potted Assembly

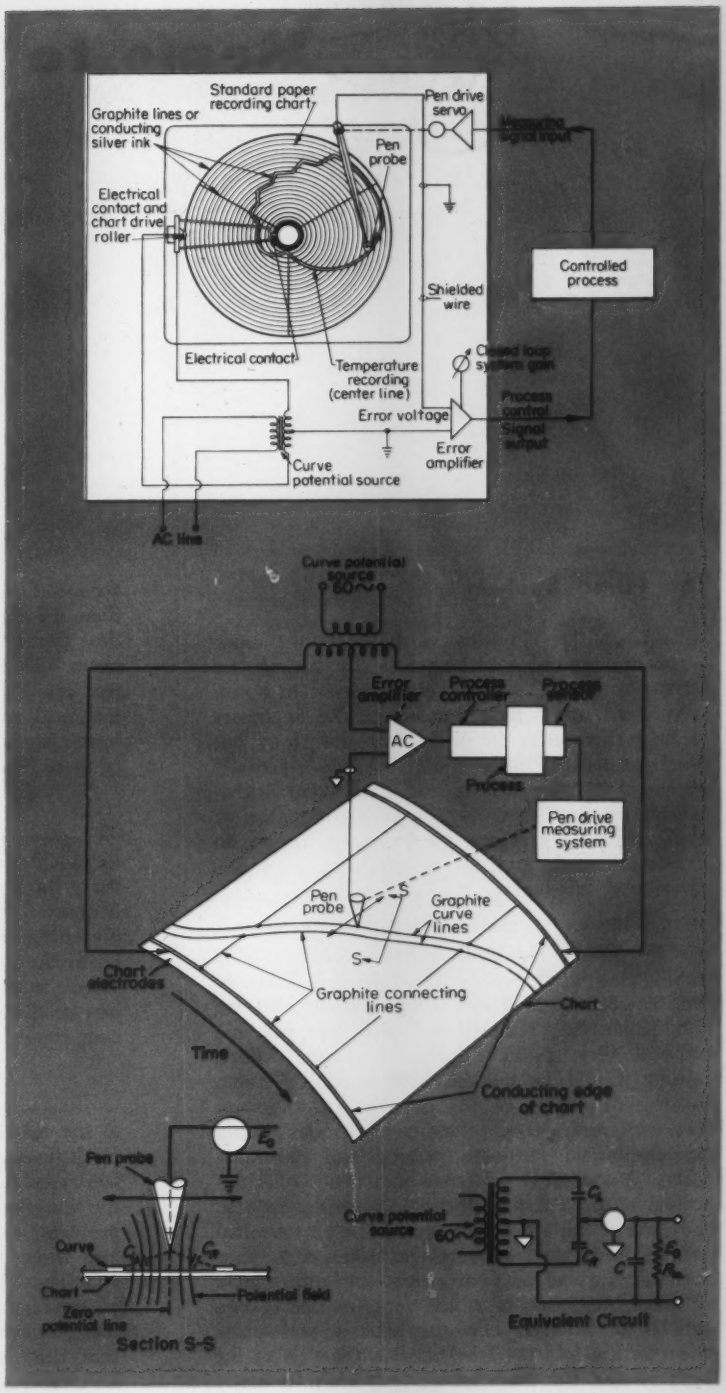


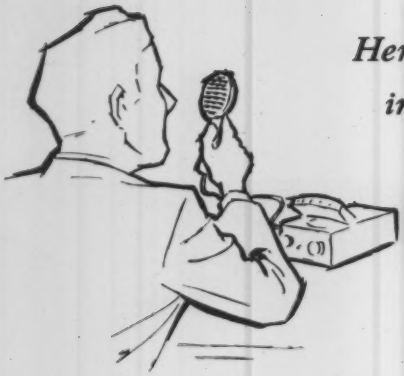
Flexible fingers of eccentric impeller "wipe" water through pump chamber. Impeller vanes or fingers made of neoprene flex in either direction making it possible to reverse the direction of impeller rotation. The pump has a check valve in the suction line to maintain a supply of priming water. If the pump is idle for a long period and priming water evaporates, a new supply of water is drawn into the chamber through the discharge spout by rotating the impeller backward for several revolutions. Impeller principle employed in a manual water pump developed by Thompson Engineering, El Monte, Calif.

Double-corkscrew idler conforms to variations in load on conveyor belt, providing uniform conveyor action. A double-spiral rubber roll is molded around a wire rope, each end of which is swaged to steel shaft. The shafts ride in ball-bearing assemblies. As the spiral turns, it "moves" along the entire width of the belt, eliminating pinching and sharp bending of the belt. Idler design developed by Hewitt-Robins Inc., Stamford, Conn.



Current-carrying graphite lines home sensing probe in on desired function to control programmed operations. A pencil line is drawn on each side of the desired function on a programming chart, such as used in conventional strip or circular-chart recorders. These lines form the curve within which the operation is to be controlled. Graphite connecting lines, drawn from the curve to a potential source (transformer), establish a uniform, potential field between the conducting lines. The process error signal is derived between the center tap of the transformer and the position of the pen probe in the potential field. Inside the boundaries of the curve, the error signal is proportional. Zero error signal occurs when the pen probe is positioned midway between the boundaries where the capacities between the pen and graphite lines are equal. Outside the boundaries, the pen probe is in a constant potential area defined by the conducting edge of the chart and the nearest of the two carbon lines forming the curve. Phase and amplitude of the error signal produced outside the curve cause the process to return to the desired program schedule. Probe sensing principle employed in the Prekorder developed by Research Inc., Hopkins, Minn.





Here are useful tips for the right-hand girl in an engineering department, listed in a

Memo to Miss Jones:

PATRICIA F. CLAYTON
Servo Corp. of America
New Hyde Park, N. Y.

The Filing System

1 The files are the heart of the department, around which practically all of the activity centers. Take an active interest in them, keep them up to date, encourage the engineers to help themselves in order that they may become acquainted with them. The do-it-yourself system eliminates waiting and consequent aggravation if a man's secretary is taking dictation or is absent. It also keeps the secretary free to do *secretarial* work and, in general, increases departmental efficiency.

2 Establish and maintain a good catalog file and a technical reference material file. A good catalog file is an engineer's dream and, if carefully planned and well kept, can become a very useful information center. Each catalog should be marked with a rubber stamp bearing the name of the department to assure its return, and a cross-reference card index should be maintained for each catalog and manufacturer. A technical reference material file is desirable to assist the engineers in keeping up with the state of the art. Set up a card file on technical articles and books of pertinent interest to your activity. Instead of saving dust-collecting stacks of magazines, each of which contains one or two articles of interest, clip the articles and place them in file folders (labeled with the title of the article) and file them where they may be easily accessible for reference. In addition, reference them in the card file under the subject matter, thus establishing a cross-reference. The engineers will help in establishing the correct subject classification both for the catalogs and the technical reference material and will aid in determining what material should be kept in each of these files.

3 In slack moments survey the files to see if they can be made more attractive by using hanging folders in addition to the standard Manila folders; see if things are conveniently placed for comfortable use (files used most should be in the top or second drawer of the cabinets). Check to see if you have any obsolete data that can be discarded or if you've accumulated duplicate copies of catalogs.

4 Let the engineers know you want to file material where they are likely to look for it. In every department there is always one man who uses the files more than anyone else. He is the man to approach for help on this practical problem, for he will give you a better insight into where an engineer would look for the things you file. There can be a vast difference between a secretary's viewpoint and an engineer's viewpoint on this subject, and it is most important that the latter's viewpoint be given preference. In most cases it can be very easily incorporated

A secretary is much more than just someone who can type, take dictation, and file. She is a confidant, an assistant, a representative of the department and the company, a person on whom you can rely to help out and remind you of important appointments. She works with the men, not for them.

These suggestions, directed to the girl in the engineering department, are made to help you help your secretary do her best. Look them over, checking off the items that apply, and perhaps adding helpful comments, then pass the article along to your "Miss Jones."

with standard filing systems learned during business training.

Technical Terminology

——————5 The language of engineering includes many "64-dollar words" which cannot be found in Webster's dictionary. A technical dictionary should therefore be kept handy at all times.

——————6 A secretary new to the field naturally will have difficulty with the technical terms peculiar to engineering. Don't feel self-conscious and don't try to bluff your way through. The boss understands and might even go so far as to offer to spell out some of the new words to help you get started. Within a couple of weeks all the rough spots will smooth out.

Outside Activities

——————7 No secretary can ever work for a man without becoming involved in his professional activities outside of the company. These activities are essential to his own personal progress, as well as beneficial to the company. It is difficult to categorize work in this capacity as being personal work because of the indirect and sometimes direct bearing it has on the work going on in the company. The meetings and conferences are of an educational nature and keep the engineers abreast of the times. Secretaries are called upon to perform tasks which may range from posting meeting notices to doing all the paper work entailed with holding an office in the society. Such work should be treated with the same importance as her daily tasks.

Confidential Information

——————8 By all means a secretary should not be a gabby or gossipy person who repeats confidences to impress her co-workers with her importance and knowledge. Any feeling of importance obtained through this medium is short-lived, and a girl who gives in to the temptation to talk will soon find that she no longer has access to confidential information. By the same token, she should keep her association with gossips to a minimum lest she inadvertently violate a confidence.

——————9 Keeping confidences is only part of what must be learned. The other part is learning how to tactfully avoid answering "nosey" questions without causing a rift in relationships. About the most tactful answer that can be given without resorting to downright lying is "I really couldn't say." It implies that you have no information to convey and actually states that you are not in a position to answer the question since it would be violating a confidence.

Design charts

+

Empirical equations

=

A simplified method for analyzing . . .

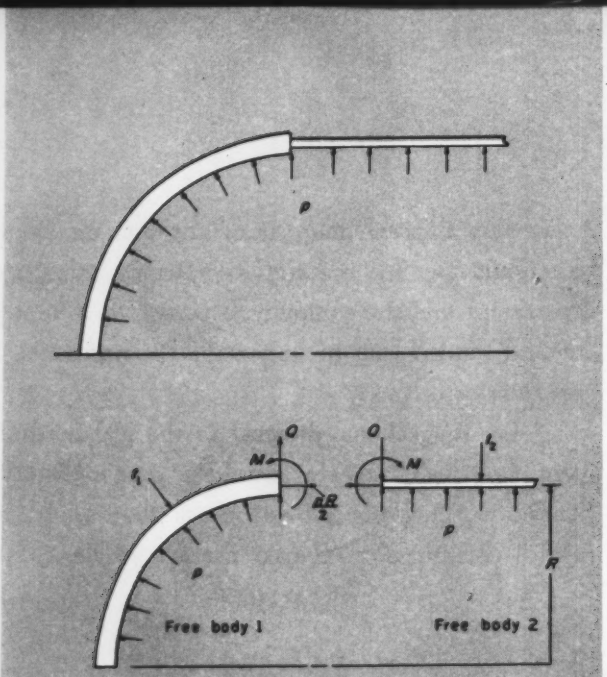


Fig. 1—Cylinder-to-head structure, separated into two free bodies for stress analysis.

Maximum Stresses in Long Cylinders

MISSILE shells and pressure vessels are probably two of the best known uses for long thin-walled cylinders. However, their application as mechanical structural elements is increasing. Why? Minimum weight.

Regardless of their use, proper analysis of cylinder strength is an important design step. But, conventional analyses leave much to be desired in the way of simplicity and ease of calculation. This article combines empirical equations with design charts to simplify the analysis of maximum stresses in long, thin-walled cylinders which are an integral part of head and shell structures.

Free Body Diagrams: In conventional methods of analysis, these structures are separated into two free bodies, with redundant shears and moments at the edge of each free body, Fig. 1. Although a structure with a hemispherical head attached to a cylindrical shell is used here for illustrative purposes, this analysis can be applied to any long cylinder with any type of head or transition element attached. Equations for edge rotation and radial edge deflection can be written for each free body in terms of known design parameters and unknown redundants.*

Hence, for free body 1 (see Nomenclature),

$$+\theta_{12} = \frac{M}{D_1\beta_1} + \frac{Q}{2D_1\beta_1^2}$$

$$+w_{12} = \frac{M}{2D_1\beta_1^2} + \frac{Q}{2D_1\beta_1^3} + \left(\frac{1}{2} - \frac{\nu}{2}\right)\frac{pR^2}{Et_1}$$

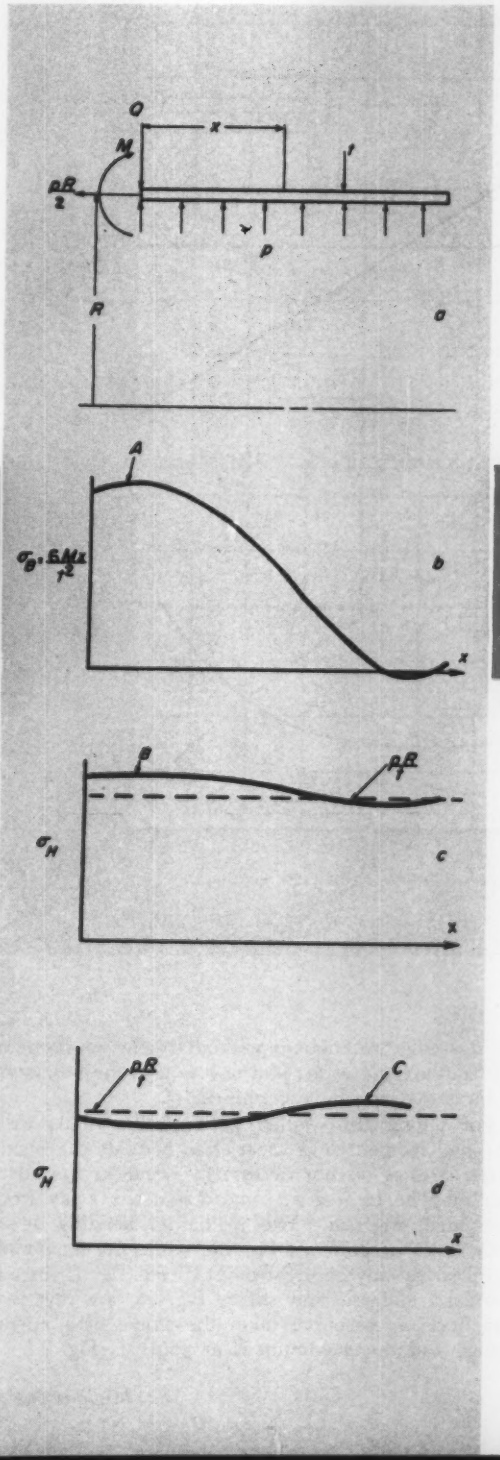
where

$$D_1 = \frac{Et_1^3}{12(1-\nu^2)}$$

$$\beta_1 = \left[\frac{3(1-\nu^2)}{R^2t_1^2}\right]^{1/4}$$

*S. Timoshenko—*Theory of Plates and Shells*, McGraw-Hill Book Co. Inc., New York, N. Y., 1940, pp. 389-410.

Fig. 2—Peak stresses in long-cylinder do not always occur at junction of cylinder and head.



EDWARD N. NELSON
Senior Analytical Engineer
Solar Aircraft Co.
San Diego, Calif.

Nomenclature

D = Flexural rigidity, lb-in.
E = Modulus of Elasticity, psi
M = Edge moment, lb-in. per in. of circumference
p = Internal pressure, psi
Q = Edge shear, lb per in. of circumference
R = Radius, in.
w = Radial edge deflection, in.
x = Distance, in.
β = Thin shell characteristic
ν = Poisson's ratio
σ_B = Bending stress, psi
σ_H = Hoop stress, psi
σ_M = Meridional stress, psi
σ_p = Pressure stress, psi
θ = Edge rotation, rad

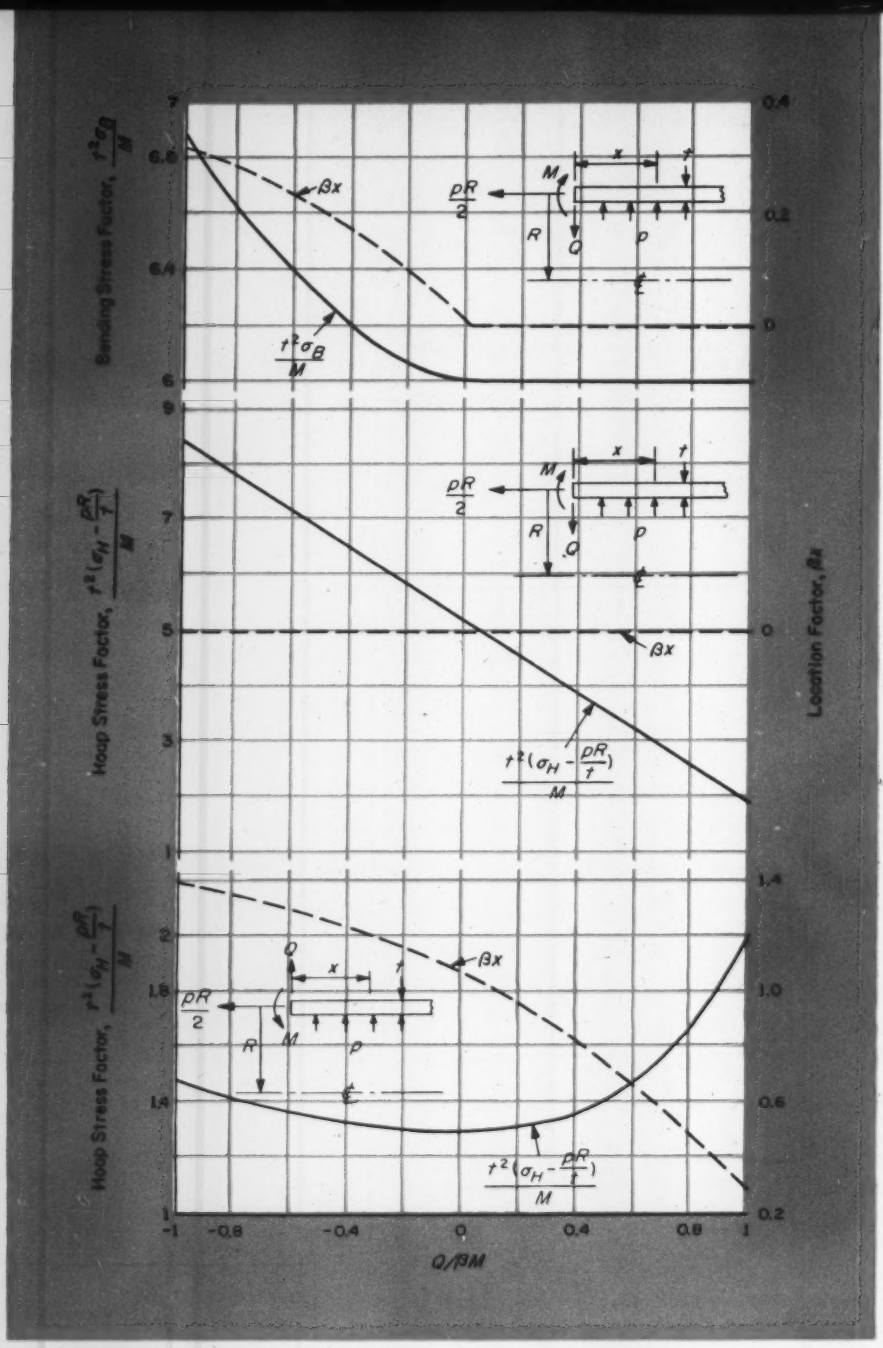


Fig. 3—Curves for obtaining maximum meridional and hoop stresses, and stress location when $-1 \leqq Q/\beta M \leqq 1$.

In a similar manner, the equations for free body 2 are

$$+\theta_{21} = -\frac{M}{D_2\beta_2} + \frac{Q}{2D_2\beta_2^2}$$

$$+w_{21} = \frac{M}{2D_2\beta_2^2} - \frac{Q}{2D_2\beta_2^3} + \left(1 - \frac{\nu}{2}\right)\frac{pR^2}{Et_2}$$

where

$$D_2 = \frac{Et_2^3}{12(1-\nu^2)}$$

$$\beta_2 = \left[\frac{3(1-\nu^2)}{R^2t_2^2}\right]^{1/4}$$

If the edge rotations and radial edge deflections are equated, $\theta_{12} = \theta_{21}$ and $w_{12} = w_{21}$, the unknown redundants can be determined.

For a long, thin-walled, pressurized cylinder with an edge moment and shear, free body 1, the maximum stresses do not necessarily occur at the edge, but may be located at some distance x away from the edge, Fig. 2*a*. The maximum bending stress may occur at point *A*, Fig. 2*b*, while the maximum hoop stress may occur at point *B*, Fig. 2*c*. If the redundant moment and shear, Fig. 2*a*, are reversed, the hoop stress curve takes the shape of a mirror image and the maximum is at point *C*, Fig. 2*d*.

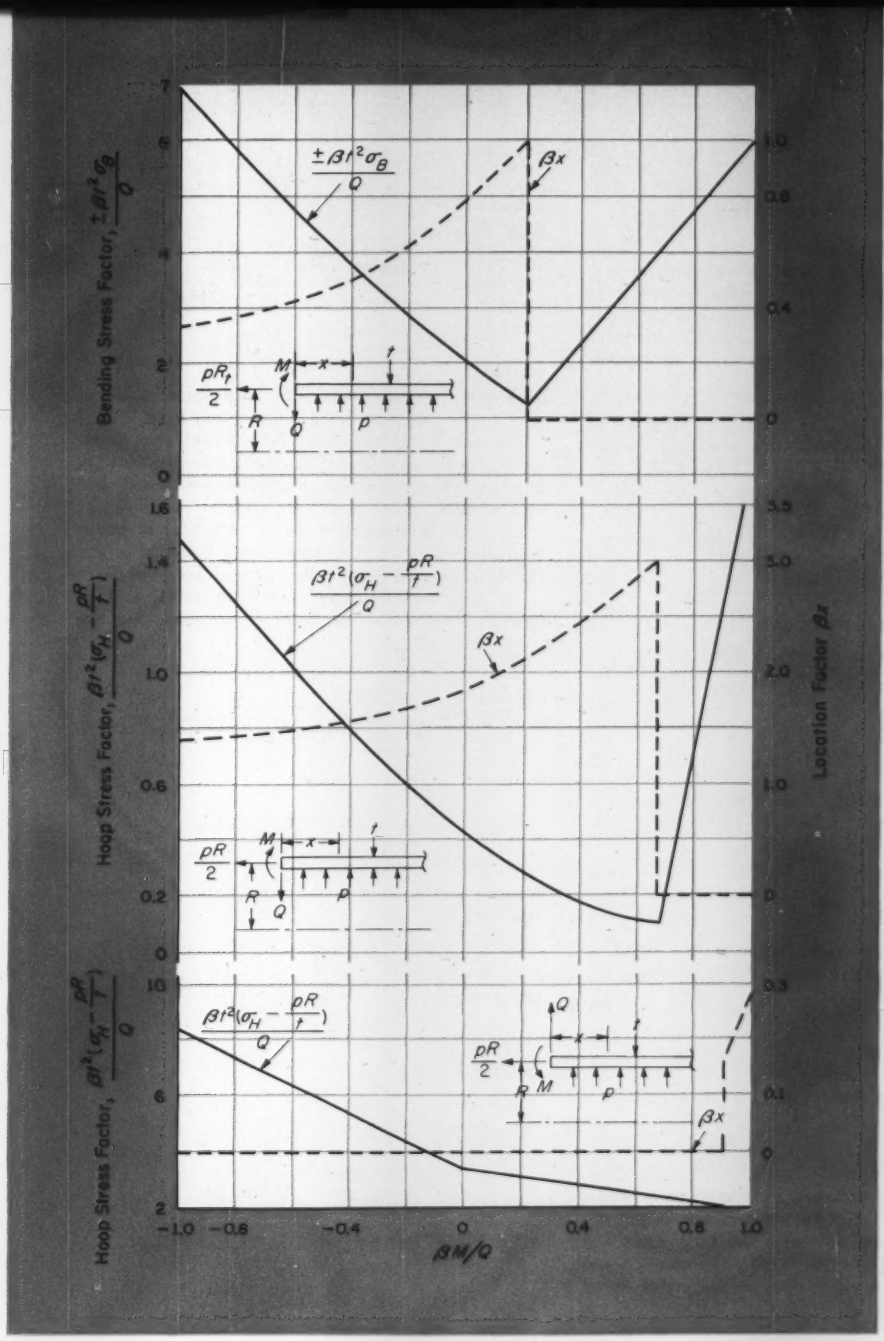


Fig. 4—Curves for obtaining maximum meridional and hoop stresses, and stress location when $-1 \leqq \beta M/Q \leqq 1$.

Meridional Stress: The general expression for meridional, or longitudinal, stress in the cylinder is

$$\sigma_M = \frac{pR}{t} \pm \frac{6}{t^2}\left[Me^{-\beta x}(\cos\beta x + \sin\beta x) - \frac{Q}{\beta} e^{-\beta x}\sin\beta x \right] \quad (1)$$

This equation gives an infinite number of peak stresses. Locations of the peak stresses are found by differentiating the stress equation with respect to distance x, setting equal to zero, and solving:

$$\cot\beta x = 1 - \frac{2\beta M}{Q} \quad (2)$$

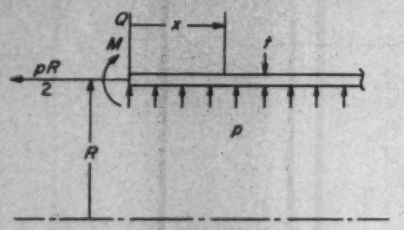
Hoop Stress: The general expression for hoop stress in the cylinder is

$$\sigma_H = \frac{pR}{t} + \frac{2\beta^2 R}{t}\left[Me^{-\beta x}(\cos\beta x - \sin\beta x) - \frac{Q}{\beta} e^{-\beta x}\cos\beta x \right] \pm \frac{6\nu}{t^2}\left[Me^{-\beta x}(\cos\beta x + \sin\beta x) - \frac{Q}{\beta} e^{-\beta x}\sin\beta x \right] \quad (3)$$

When Equation 3 is differentiated with respect to distance x and the differential is set equal to zero, the locations of the peak hoop stresses are obtained

Design Examples

EXAMPLE 1: A long cylinder with radius $R = 30$ in. and thickness $t = 0.15$ in. is subjected to an internal pressure $p = 900$ psi. If the cylinder has an edge moment, $M = 115$ lb-in. per in. of circumference, and an edge shear, $Q = 10$ lb per in. of circumference, determine the maximum meridional and hoop stresses.



Calculate the value of β and $Q/\beta M$:

$$\beta = \left[\frac{3(1-\nu^2)}{R^2t^2}\right]^{1/4} = \left[\frac{3(1-0.3^2)}{30^2(0.15^2)}\right]^{1/4} = 0.605 \quad \ldots(5)$$

$$\frac{Q}{\beta M} = \frac{10}{0.605(115)} = 0.144 \quad (6)$$

Determine the bending stress and location factors from Fig. 3 for $Q/\beta M = 0.144$:

$$\text{Bending stress factor} = \pm\frac{t^2\sigma_B}{M} = 6 \quad (7)$$

$$\text{Location factor} = \beta x = 0 \quad (8)$$

The maximum meridional stress at the point of maximum bending stress is

$$\sigma_{M,max} = \sigma_p + \sigma_{B,max} \quad (9)$$

where $\sigma_p = pR/2t$

Hence, from Equations 7 and 9,

$$\sigma_{M,max} = \frac{pR}{2t} \pm \frac{6M}{t^2} = \frac{900(30)}{2(0.15)} \pm \frac{6(115)}{(0.15)^2}$$

$$= 90{,}000 \pm 30{,}650 = 120{,}650 \text{ psi}$$

Since $\beta x = 0$, the maximum meridional stress occurs at $x = 0$, the junction of the cylinder and head.

For the hoop stress, determine the hoop stress and location factor for $Q/\beta M = 0.144$. The moment and shear loadings correspond to those for the center curves in Fig. 3. Hence,

$$\text{Hoop stress factor} = \frac{t^2\left(\sigma_H - \frac{pR}{t}\right)}{M} = 4.60 \quad (10)$$

$$\text{Location factor} = \beta x = 0 \quad (11)$$

From Equation 10,

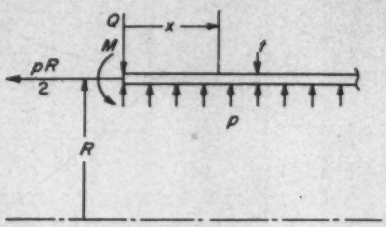
$$\sigma_{H,max} = \frac{4.60\,M}{t^2} + \frac{pR}{t} = \frac{4.60(115)}{(0.15)^2} + \frac{900(30)}{0.15} = 203{,}500 \text{ psi}$$

Since $\beta x = 0$, the maximum hoop stress occurs at $x = 0$, the junction of the cylinder and head.

EXAMPLE 2: Assume that the moments and shears acting on the cylinder of *Example* 1 are reversed in direction. Determine the maximum meridional and hoop stresses.

Since the bending stress factor is a plus or minus term, the maximum meridional stress, Equation 9, and the stress location remain the same as for *Example* 1.

To determine the maximum hoop stress, and its location, the lower curves of Fig. 3 are used, since the



moment and shear directions match the given values. From Fig. 3

$$\text{Hoop stress factor} = \frac{t^2\left(\sigma_H - \frac{pR}{t}\right)}{M} = 1.3 \quad (12)$$

$$\text{Location factor} = \beta x = 0.99 \quad (13)$$

Hence, from Equation 12

$$\sigma_{H,max} = \frac{1.3\,M}{t^2} + \frac{pR}{t} = \frac{1.3(115)}{(0.15)^2} + \frac{900(30)}{0.15} = 186{,}640 \text{ psi}$$

From Equations 5 and 13,

$$x = \frac{0.99}{\beta} = \frac{0.99}{0.605} = 1.64 \text{ in.}$$

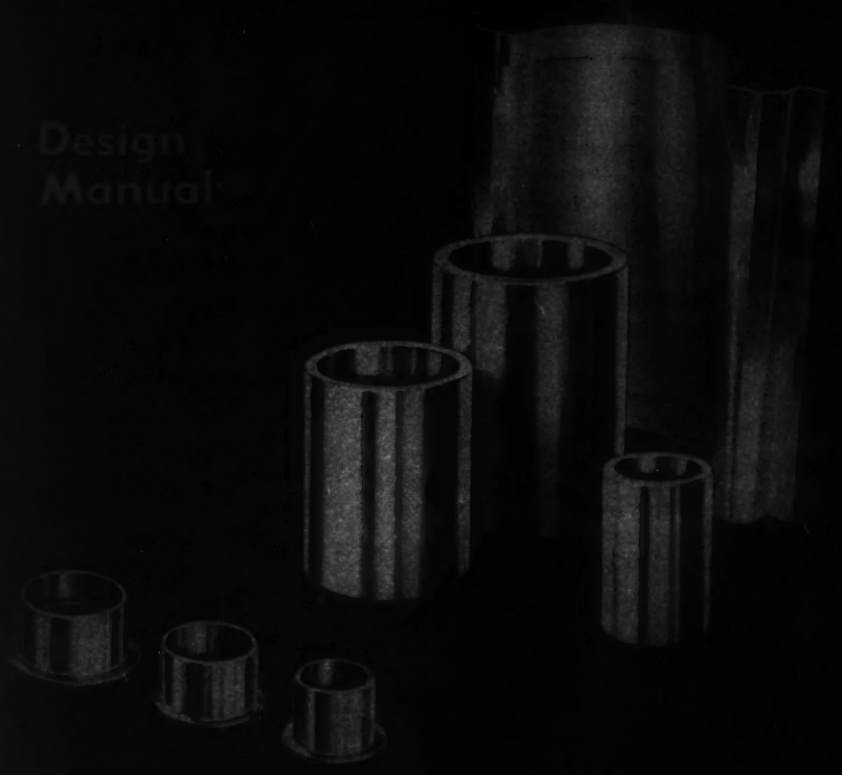
If the value of $Q/\beta M$ in these examples had been greater than 1, the reciprocal, $\beta M/Q$, would have been determined, and the graphs of Fig. 4 would have been used for calculations.

from

$$\tan \beta x = \frac{\left[-\left(1 - \frac{2\beta M}{Q}\right) \pm \frac{3\nu}{[3(1-\nu^2)]^{1/2}}\right]}{\left[1 \pm \frac{3\nu}{[3(1-\nu^2)]^{1/2}}\left(1 - \frac{2\beta M}{Q}\right)\right]} \quad (4)$$

Maximum Stresses: To find the maximum stresses, the meridional and hoop stresses are calculated at the edge and at the first two peak points. Equations 1 through 4 for the location and magnitude of the peak stresses can be expressed in terms of the non-dimensional parameter, $\beta M/Q$, where $\beta M/Q$ can have any magnitude. To help in maximum stress calculations, the graphs, Fig. 3 and 4, are presented in two ranges. Fig. 3 is for $-1 \leqq Q/\beta M \leqq +1$ and Fig. 4 is for $-1 \leqq \beta M/Q \leqq +1$. The curves in both figures are valid only for materials with $\nu = 0.3$.

Design Manual



Bronze Sleeve Bearings

Design and analysis of sleeve bearings to determine:

- **Bearing Size**
- **Clearances**
- **Oil-Flow Rates**
- **Operating Temperatures**
- **Power Required**
- **Lubricant Film Thickness**
- **Journal Eccentricity Ratio**
- **Whirl Speed**
- **Allowable Shock Load**

Design Manual:

Cast Bronze

Sleeve bearings offer a number of desirable operating characteristics. But sleeve bearings, in contrast to other bearing types, have always suffered from lack of fast, simple design techniques.

An integrated program of articles—of which this Design Manual is the first part—will present techniques answering most of an engineer's requirements for an easy-to-use design method. Although the methods and information were developed specifically for cast-bronze bearings, the procedures are broadly applicable to sleeve bearings of other materials.

This Manual, and the articles which will follow in future MACHINE DESIGN issues, represents research conducted at the Friction and Lubrication Branch of The Franklin Institute. The program was sponsored by the Cast Bronze Bearing Institute.

Design and application of 360-degree bronze bearings is fully covered in this Design Manual for full-film, boundary, and mixed-film lubrication. New design methods and numerous graphs reduce actual calculations to a minimum for quick determination of bearing configurations. Detailed explanations tell how to predict load-carrying capacity, power requirements, lubricant requirements, stability, and operating temperatures. Bearing clearances are recommended for various classes of machinery and shaft sizes. Special problems caused by shock loads and heavy loads at slow speeds are analyzed.

Future articles will present additional information on lubricating fluids, including a method for determining viscosity. Several methods are described for applying lubricant. Determining shape and dimensions of grooves in bearing surfaces is illustrated for each type of lubrication. Properties of cast-bronze bearing materials are also discussed.

In addition to Mr. Rippel, other participating members of the Friction and Lubrication Branch of The Franklin Institute Laboratories are: D. D. Fuller, principal scientist, J. Hinkle, A. M. Loeb, S. B. Malanoski, R. Pandolfi, S. Richardson, G. M. Robinson, W. W. Shugarts, and C. Stevenson.

STATED simply, the designer's problem from the standpoint of bearings is: Provide suitable bearings to support the moving system in a trouble-free manner when operating at the given speeds and subjected to the given loads.

A typical "moving system" is shown schematically in Fig. 1. The system is to be supported by "suitable bearings." Type and speed of motion is usually dictated, as are the types and magnitudes of loads. In addition, diameter of the shaft in the vicinity of the bearings is also normally specified to meet certain strength or stiffness considerations within the system. Knowing speed, load, and size requirements, the designer can proceed to design trouble-free bearings. "Trouble-free" usually means long service life, low friction, and minimum maintenance.

At this stage in the development of suitable bearings, the present-day designer selects rather than designs such bearings. Actual design of bearings, such as the bronze sleeve bearing, is becoming a lost art. Most bronze bearings being designed today have, as the basis for their design, bearings used in previous, similar applications which proved successful. The experienced bronze-bearing designer relies heavily upon his past experience. This practice is both good and bad—good in that a workable design can be arrived at in a short time, and bad in that what's best in one case may not be best for a similar application.

Cast Bronze Bearing Institute

CBBI was formed March 6, 1958, by nine producers of finish-machined cast-bronze bearings. Their purpose: To promote the use of cast bronze bearings and bushings through research, development, education, and promotion.

The Institute voted to affiliate with Non-Ferrous Founders' Society Inc. and subsequently became the first product group of that organization. CBBI was incorporated March 27, 1958.

First action of CBBI was to contract with The Franklin Institute for a systematic survey of engineering data pertinent to cast-bronze bearings. The ultimate goal was a technical manual for the engineer —presented in this program of articles—giving all information necessary for design, selection, and use of cast-bronze bearings and bushings.

Original Members of CBBI

American Crucible Products Inc., Lorain, Ohio
Beckett Bronze Co., Muncie, Ind.
Moccasin Bushing Co., Chattanooga, Tenn.
National Bearing Div., American Brake Shoe Co., St. Louis, Mo.
Randall Graphite Bearings Inc., Lima, Ohio
Renewal Service Inc., Philadelphia, Pa.
Ryder Brass Foundry Co., Bucyrus, Ohio
Superior Kendrick Bearings Inc., Detroit, Mich.
Wisconsin Centrifugal Foundry Inc., Waukesha, Wis.

Sleeve Bearings

HARRY C. RIPPEL
Senior Research Engineer, The Franklin Institute Laboratories, Philadelphia

The prime purpose of this Manual is to present sufficient engineering data to permit design and performance prediction of bronze sleeve bearings. On this basis, a bearing design can be accepted or rejected for use in a particular application.

Description of a Sleeve Bearing

Sleeve bearings are quite probably the most used machine element in our civilization. They are of many sizes, shapes, and configurations, but they consist essentially of a band or sleeve of close-fitting material that encloses and supports a moving member. Fig. 2 shows a typical bronze sleeve bearing and the member being supported. Usually, the sleeve is stationary and is called the bearing. The moving member is usually referred to as the journal. Other names for sleeve bearings are journal bearings, since they support journals, and radial bearings, since all loads supported are in the radial direction or perpendicular to the axis of the journal.

Important physical dimensions of the sleeve bearing in Fig. 2 are journal diameter D, bearing length

C = Radial clearance, in.
D = Journal diameter, in.
F = Bearing friction force, lb
f = Coefficient of friction
$= F/W$
L = Bearing length, in.
N = Rotational speed of journal, rpm
p = Projected area unit load, psi
$= W/LD$
W = Steady load to be suported, lb
W_m = Dead weight of rotating parts, lb
W_s = Shock load, lb
Z = Lubricant absolute viscosity, centipoise

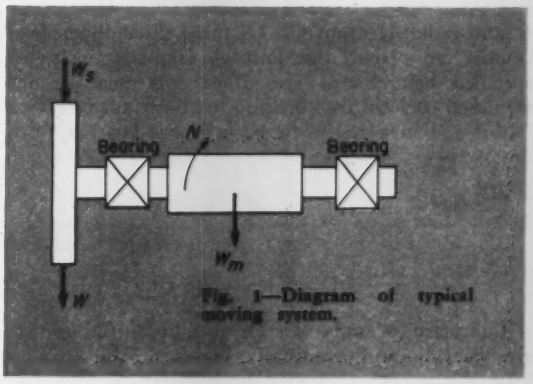


Fig. 1—Diagram of typical moving system.

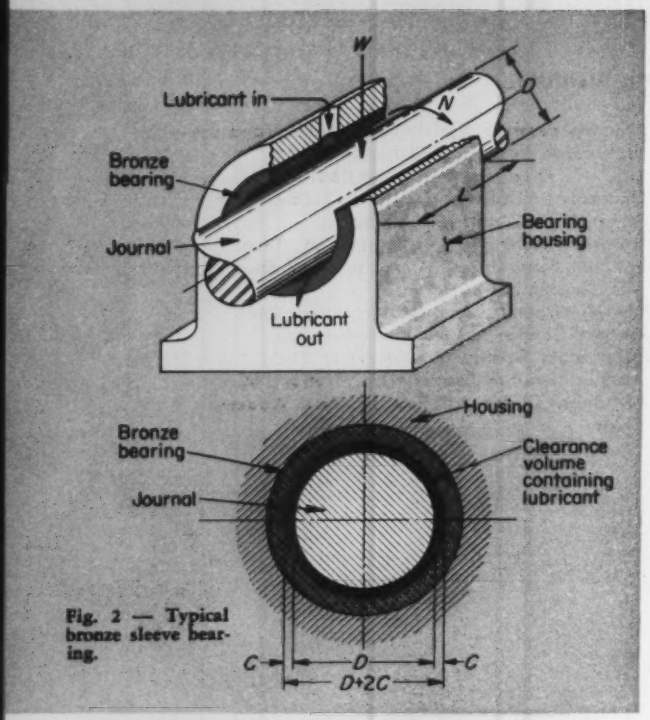


Fig. 2 — Typical bronze sleeve bearing.

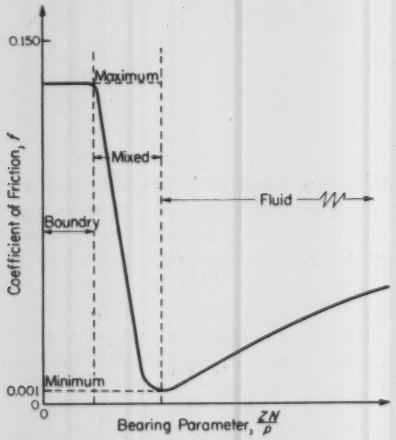


Fig. 3—Variation of coefficient of friction with ZN/p for bronze sleeve bearings.

L, and radial clearance C. Of these three dimensions usually only one, the journal diameter, may be specified beforehand. The other two must be determined before the bearing can be made. Two useful and meaningful terms in sleeve-bearing work are:

$$\frac{2C}{D} = \text{Clearance ratio} \qquad (1)$$

$$\frac{L}{D} = \text{Length-to-diameter ratio}$$

Lubricant of some sort is usually introduced to the bearing and eventually leaves at the ends of the bearing. Consequently, lubricant must be continuously or periodically replaced. Some functions of the lubricant in a bearing are:

1. Reducing friction.
2. Removing some of the heat generated.
3. Minimizing wear of the rubbing parts.

Properties of the lubricant of most concern are absolute viscosity and ability to cling to bearing members.

Types of Sleeve-Bearing Operation

There are three types or realms of sleeve-bearing operation. Proper classification and definition is important since the design and operating characteristics are different for each. The three types are:

1. Full-film or hydrodynamic lubrication. (Hydrostatic lubrication is also full-film.)
2. Complete boundary lubrication.
3. Mixed-film lubrication.

Full-film lubrication physically separates the journal from the bearing by a relatively thick (on the order of 0.001 in.), continuous film of self-pressurized lubricant with no metal-to-metal contact. This happy state of affairs is also termed "hydrodynamic lubrication." Low friction and infinitely long service life can be obtained provided a supply of clean lubricant of the right viscosity and sufficient quantity is continuously maintained.

Full-film is the ideal type of lubrication for bronze bearing operation and should be strived for when feasible in order to reap the benefits of low power loss, almost infinite life, and low cost. Sleeve-bearing coefficients of friction for full-film lubrication are on the order of 0.005. However, coefficients of friction of 0.001 or less can be obtained from bronze sleeve bearings in certain applications.

Complete boundary lubrication indicates that the bearing and journal surfaces are being rubbed together in the presence of an extremely thin film of lubricant which adheres to the surface of both the journal and the bearing. Unless the bearing is relubricated periodically, the thin film is eventually destroyed and intimate metal-to-metal contact results. For bronze bearings operating under conditions of complete boundary lubrication, the coefficient of friction may vary over a range of approximately 0.08 to 0.14. A bronze alloy with a high percentage of lead (15 to 25 per cent) is recommended for extreme boundary conditions.

*Mixed-film lubrication** is, as the name implies, a combination of hydrodynamic and boundary lubrication. That is, part of the total load carried by the bearing is being supported by individual load-carrying pools of self-pressurized lubricant and the remaining part by the very thin contaminating film associated with boundary lubrication. Coefficients of friction in this realm of operation are in the range of 0.02 to 0.08.

*Common current practice is to combine boundary film and mixed-film lubricated sleeve bearings under the one title of "boundary lubrication." However, in this Manual, they are treated separately.

Lubrication and Friction: Fig. 3 indicates in a very general way the picture of bronze sleeve-bearing performance. This slightly modified version of a diagram familiar to bearing designers consists of a plot of coefficient of friction versus bearing parameter ZN/p. The figure is separated into three distinct regions to indicate the three realms of sleeve-bearing operation.

At the extreme right of Fig. 3, which corresponds to the higher values of ZN/p, is the full-fluid-film or hydrodynamic lubrication region. Under full-film conditions, the coefficient of fluid friction is seen to be approximately proportional to viscosity and speed and inversely proportional to load. The coefficient attains a minimum value of approximately 0.001, which is also the minimum coefficient of friction for a good precision grade of rolling-element bearing.

At the extreme left-hand side of Fig. 3 the curve levels off at a high value for the coefficient of friction and remains constant. This portion of the curve is recognized as the region of true boundary friction where the coefficient of friction is independent of viscosity and rubbing speed. Thus, for small values of ZN/p, the coefficient of friction remains essentially constant. Its magnitude will normally lie between 0.08 and 0.14 depending upon the bearing materials and the lubricant used.

Between the boundary and full-film zones of lubrication (they may also be called zones of friction) is the zone where, with reduction in ZN/p, the coefficient of friction increases sharply. Evidence indicates that in this zone a combination of fluid friction and boundary friction exists; hence, it bears the title "mixed friction" or "mixed lubrication." The exact values of ZN/p at which the transition from complete boundary to mixed-film lubrication occurs, and also from mixed-film to full-film lubrication, is difficult to predict. These transition points depend upon such variables as:

1. Quantity of lubricant available.
2. Ability of the lubricant to adhere to bearing surfaces under adverse conditions.
3. Rigidity of bearing and journal.
4. Bearing and journal materials.
5. Operating temperature of bearing.
6. "Wearing-in" of bearing.

Bronze sleeve bearings in common use today are called upon to operate in one or more of these three types of lubrication. For instance, the sleeve bearings of a small fan motor may be squirted with oil at the beginning of summer so that on June 1 the bearings may have an abundance of lubricant. Because of light load and high speed, the bearings will probably operate on a full film until they lose their copious supply of lubricant. Thus, on June 2 the bearings probably will be operating under mixed-film conditions. Certainly by the time the fan is ready for winter storage, the bearings will be operating on a very thin boundary film with no ill effects. Small hand-tool and appliance motors fall into the same category. Usually the bearings for such motors are small in size and very lightly loaded. They are capable of years and years of service with just the barest of lubrication.

In direct contrast are the large turbine-generator sleeve bearings on which are generated practically every kilowatt of electrical power and which are continuously operated only under full-film conditions. Elaborate precautions are taken to insure that such bearings receive a copious supply of clean lubricant of the right viscosity. Such bearings fulfill what is perhaps one of the most demanding tasks in our present civilization—100 per cent reliability. A classic example of a large-size sleeve bearing which operates in all three regions of lubrication is the journal bearing used for railroad freight cars.

Full-Film Operation: Conditions which are necessary to promote full-film or hydrodynamic operation are:

1. Bearing characteristic number should lie within a specified range.
2. Relative surface speed should be greater than approximately 25 fpm and continuous in one direction. Rotation in the opposite direction is also possible provided the motion is not oscillatory in nature. Exceptions are pulsating loads such as occur in engine wrist pins.
3. Lubricant should have the proper viscosity.
4. Lubricant at the proper rate should be continuously supplied to the bearing, and the flow must not be less than a specified minimum rate.
5. The bearing must be properly designed to promote and maintain full-film hydrodynamic lubrication.

Full-film lubrication under very high-load, very slow-speed conditions is possible by using hydrostatic lubrication. Extremely low coefficients of friction (zero at zero speed) can be realized using this type of lubrication. Also, starting and stopping under load can be easily accomplished. Since hydrostatic lubrication requires external pumps, bearings of this type are costly but offer advantages not found in any other type of bearing.

Mixed-Film Operation: Bronze bearings which usually operate in the mixed-film lubricated realm of sleeve bearing operation are:

1. All oil-lubricated bearings which are supplied a continuous but relatively small amount of lubricant if the oil-supply rate is less than some specified rate and the surface velocity is greater than 10 fpm.
2. Bearings supplied by drop-feed oilers, wicks, bottle oilers, mechanical oilers, and other types of low-feed-rate devices.
3. Bearings subjected to oscillatory motion if relative surface speeds are greater than 10 fpm.

Complete Boundary Operation: Bronze bearings which usually operate in the complete boundary lubricated realm of sleeve bearing operation are:

1. Grease-lubricated bearings.
2. Bearings which are periodically relubricated, as by hand oiling or greasing.
3. Bearings used for reciprocating motion applications (motion along the axis of the shaft).
4. Bearings used in very slow-speed applications where relative velocity between shaft and bearing is less than 10 fpm.

- Bearing Clearance Ratios
- Bearing Characteristic Number
- Journal Eccentricity Ratio
- Bearing Length
- Power Requirements
- Oil-Feed Requirements
- Minimum Flow Requirements
- Oil-Film Temperature
- Simplified Design Method
- Heavily Loaded Bronze Bearings
- Shock-Loaded Bronze Bearings
- Lightly Loaded, High-Speed Bearings
- Hydrostatic Lubrication

Full-Film Lubrication

PRESENCE of hydraulic pressure in the oil film of a sleeve bearing was discovered in 1883. Later, it was explained and proved that full-film lubrication was the result of hydrodynamic action. In a properly lubricated sleeve bearing, lubricant adheres to both the journal and the bearing. As a result of journal rotation, lubricant is drawn into the converging region formed by the displaced journal in the bearing. Because of lubricant viscosity, fluid pressure is generated in the lubricant film separating the bearing members. This fluid pressure provides the load-carrying capacity in a bronze sleeve bearing.

General shape of the pressure distribution that exists in a bronze sleeve bearing operating on a full film of lubricant is indicated in Fig. 4. Both axial and circumferential pressure distributions are shown. Magnitudes and shapes of the fluid pressure distributions will vary depending upon such factors as load, speed, clearance ratio, and lubricant viscosity. How to determine magnitude and shape of the pressure distribution is described later.

Distinct steps in the formation of the fluid film in a bronze bearing are shown in Fig. 5. When the bearing is at rest, no lubricant separates the bearing members. When the journal begins to rotate, it first "climbs" the wall of the bearing in a direction opposite to rotation. Actually, it rolls up the wall because of friction between journal and bearing. As soon as the friction-force component in the direction of the load is overcome, the journal falls down the wall and crosses to the other side of the bearing. As speed increases, the journal draws more lubricant into the converging wedge until it is completely supported on a full film of lubricant with no metal-to-metal contact. Properly designed and continuously supplied with clean lubricant of the proper viscosity and quantity, the bronze bearing will operate forever with absolutely no wear and extremely low friction.

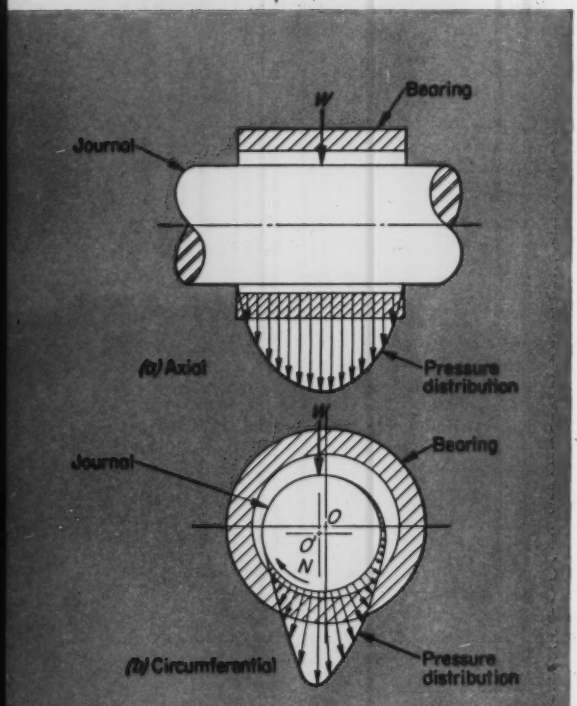


Fig 4—Pressure distributions in a full-film lubricated bronze bearing.

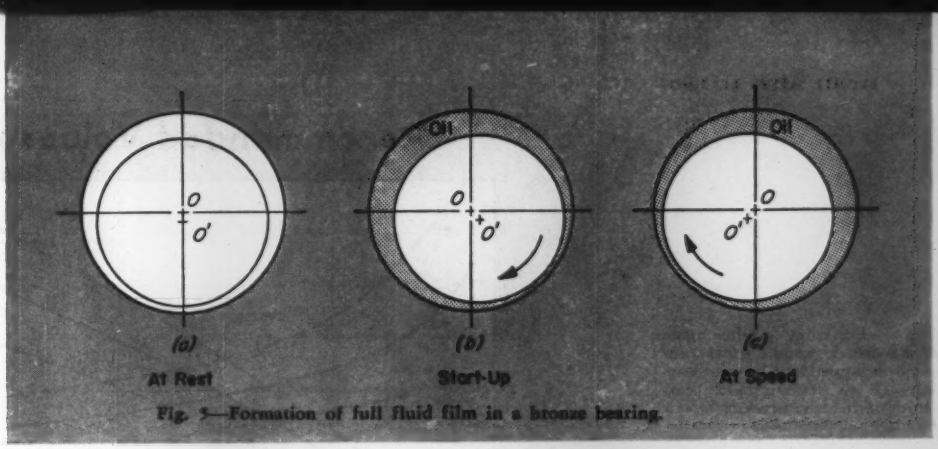


Fig. 5—Formation of full fluid film in a bronze bearing.

Such performance is the dream of every designer and is readily obtained by using the basic principles and recommendations which follow. After individual factors are discussed, a chart outlines the use of these factors in the actual design procedure. Given conditions are listed first, and other data are easily read from charts and tables. Preliminary calculations provide condensed factors for final computations. The actual ten-step method starts with an assumed bearing bore temperature. With this value, the remaining bearing information is determined and a temperature balance is obtained. If the final temperature does not agree with the initially assumed temperature, a different bore temperature is selected and the ten steps repeated until assumed and calculated temperatures are approximately the same.

Therefore, in the sections which follow, equations and charts are presented, discussed in detail, and ultimately combined into a simple work sheet for designing bronze sleeve bearings under full-film lubrication. A sample design then illustrates the method.

Bearing Clearance Ratios

Often, some confusion results when specifying clearances for bronze sleeve bearings because of the various methods of expressing this clearance. For use in this Manual, terms regarding bearing clearance are defined as:

Diametral clearance, $2C$, equal to bearing bore diameter minus journal diameter.

Radial clearance, C, equal to bearing bore radius minus journal radius.

Clearance ratio, $2C/D$, equal to diametral clearance divided by journal diameter.

Because C is much, much smaller than D, clearance ratio is multiplied by 1000 to obtain numbers

Nomenclature

A = Bearing characteristic number
C = Radial clearance, in.
c_p = Specific heat of lubricant, Btu/lb-deg F
D = Journal diameter, in.
D_B = Bearing bore diameter, in.
e = Eccentricity, or radial displacement of journal, in.
h_o = Minimum film thickness of lubricant, in.
K_1 = Ventilation factor, Table 1
k_s = Whirl speed factor
k_f = Frictional power factor
k_q = Side-leakage flow factor
k_s = Shock load factor
k_1, k_2, k_3, k_4, k_5 = Factors used in Table 2
L = Bearing length, in
m = Clearance factor
= $1000(2C)/D$
N = Rotational speed of journal, rpm
N_c = Half-frequency whirl speed of shaft, rpm
O = Actual center location of bearing
O' = Actual center location of displaced journal
P_F = Frictional horsepower generated within full-film lubricated bearing, hp
p = Projected area unit load, psi
= W/LD
Q = Side-leakage oil-flow, or oil-flow feed rate, gpm or drops per min
Q' = Minimum oil-flow required for full-film lubrication, gpm or drops per min
s = Lubrication factor, Table 1
= $(T_2 - T_3)/(T_4 - T_3)$
T_1 = Oil inlet temperature, F
T_2 = Lubricant film temperature for full-film conditions, or bearing bore temperature for mixed-film and boundary conditions, F
T_3 = Surface temperature of bearing housing, F
T_4 = Ambient atmosphere temperature, F
t_B = Bearing bore "plus" tolerance, in.
t_J = Journal diameter "minus" tolerance, in.
Δt = Duration of shock load, sec
W = Steady load to be supported, lb
W_m = Dead weight of rotating parts, lb
W_s = Shock load, lb
Z = Lubricant absolute viscosity, centipoise
γ = Lubricant density, lb per gal
ε = Journal eccentricity ratio
ε_o = Journal eccentricity ratio before shock load
ε_1 = Journal eccentricity ratio at end of shock load
ϕ = Angle between direction of load and direction of journal displacement, deg

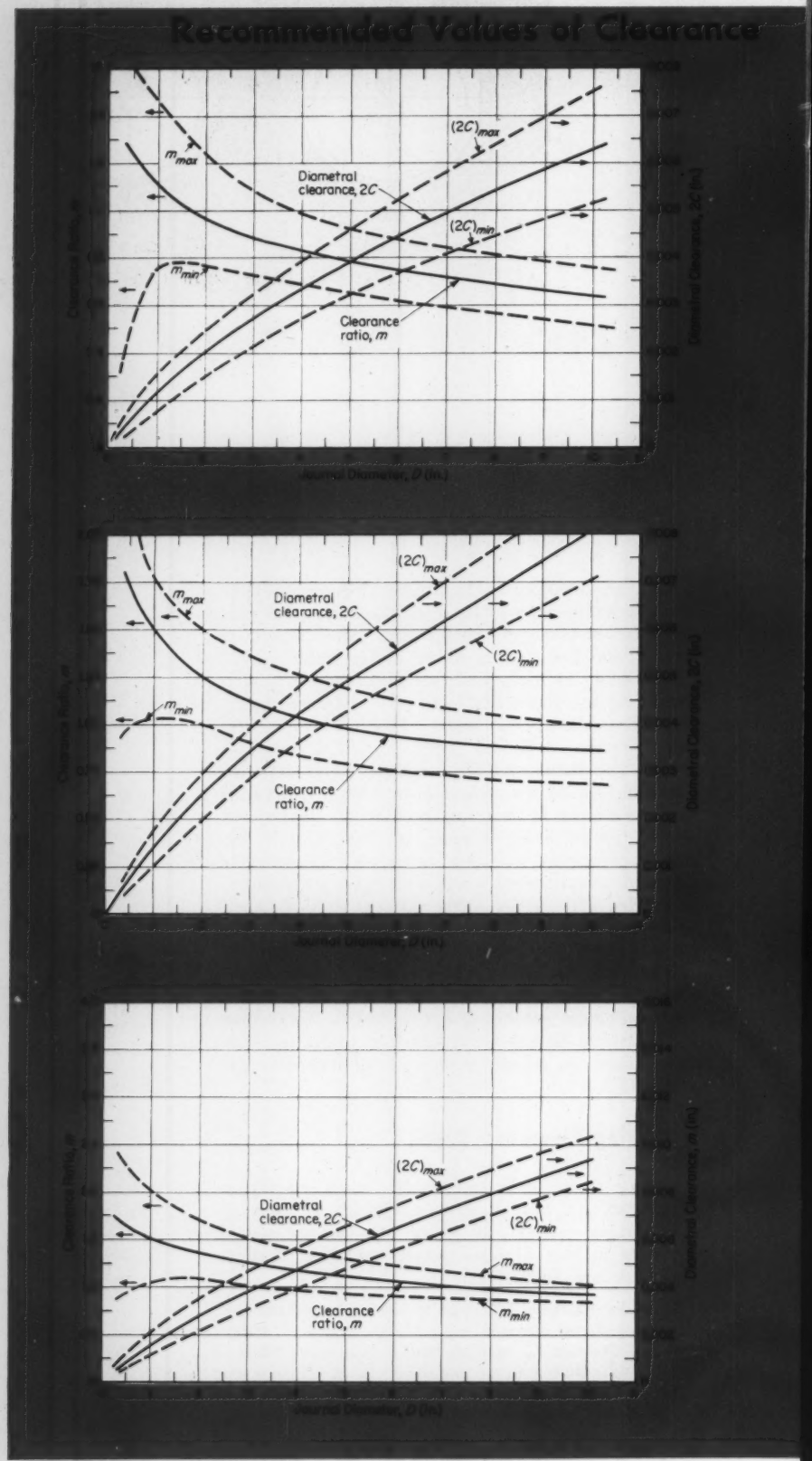


Fig. 6—Precision spindles made of hardened, ground steel running on lapped cast-bronze bearings (8 to 16 microinch rms finish) when the product *DN* is less than 2000.

Fig. 7—Precision spindles made of hardened, ground steel running on lapped cast-bronze bearings (8 to 16 microinch rms finish) when the product *DN* is more than 2000.

Fig. 8—Electric motors, generators, and similar types of machinery using ground journals in broached or reamed cast-bronze bearings (16 to 32 microinch rms finish).

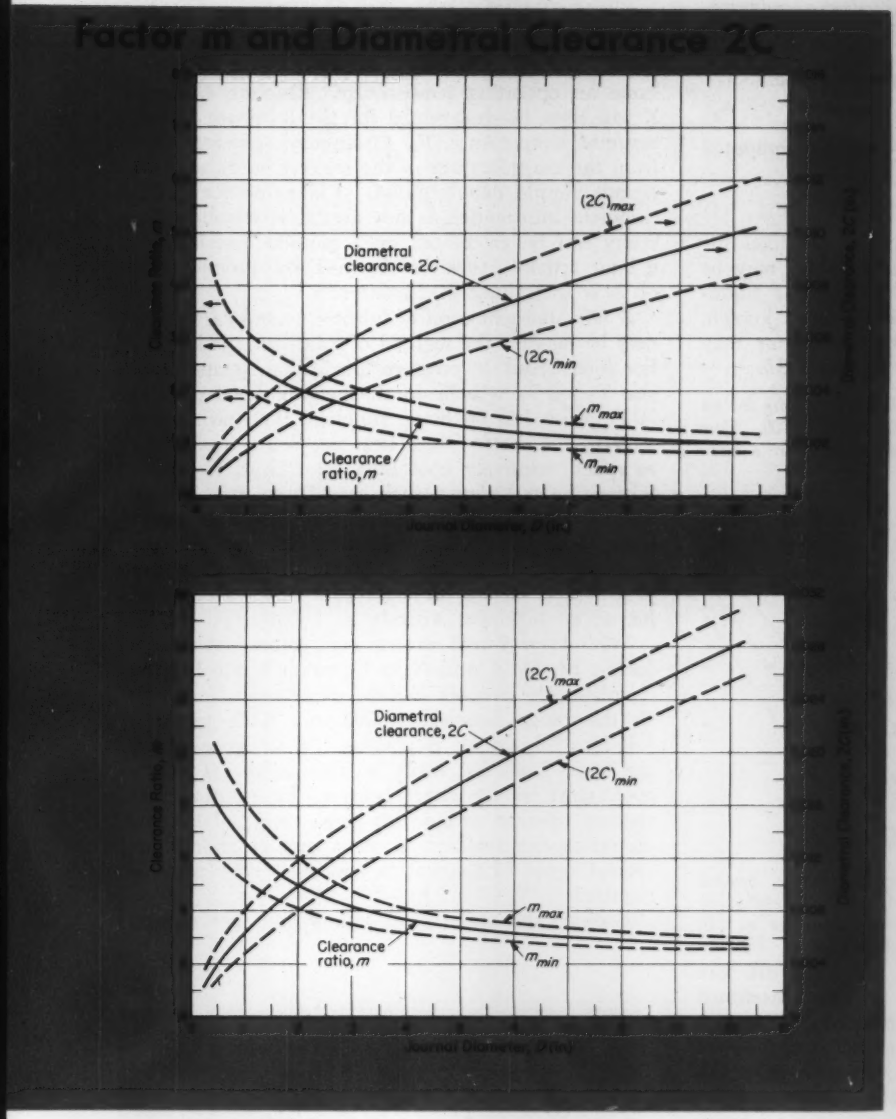


Fig. 9 — General machinery which continuously rotates or reciprocates and uses turned or cold-rolled steel journals in bored and reamed cast-bronze bearings (32 to 63 microinch rms finish).

Fig. 10 — Rough-service machinery having turned or cold-rolled steel journals operating on cast-bronze bearings (63 to 125 rms finish).

more convenient to use. This modified ratio is termed "clearance factor" and is

$$m = 1000\left(\frac{2C}{D}\right) \tag{2}$$

As a useful guide to determining bearing clearance factor m, first identify the particular application with one of the descriptions given for Fig. 6 through 10. Then, a recommended value for m can be obtained from the figure for that type of machinery. Two sets of curves are shown on each of the figures. One set indicates average recommended values for m and also shows the range within which the designer may obtain acceptable results. The second set shows similar curves for the resulting diametral clearances, $2C$, obtained when using the suggested values of m. In general, these clearance factor values may also be used for mixed-film and complete boundary film operating conditions.

Journal and Bore Tolerances: When dimensions and tolerances for journal and bore are specified, the following practice is recommended:

Journal diameter should be specified as

$$D = D_{nom}{}^{+0.0000}_{-t_J} \tag{3}$$

and bearing bore diameter as

$$D_B = (D_B)_{nom}{}^{+t_B}_{-0.0000} \tag{3a}$$

When the two diameters are specified as above, minimum diametral clearance will be

$$(2C)_{min} = (D_B)_{nom} - D_{nom} \tag{3b}$$

and maximum diametral clearance will be

$$(2C)_{max} = [(D_B)_{nom} - D_{nom}] + t_B + t_J \quad (3c)$$

The allowable tolerances may then be computed from

$$t_B + t_J = (2C)_{max} - (2C)_{min} \quad (4)$$

Both $(2C)_{min}$ and $(2C)_{max}$ may be obtained directly from Fig. 6 through 10, and values may be conveniently assigned to t_B and t_J by using Equation 4. If the nominal journal diameter is known, the required nominal bearing bore diameter may be determined directly by using Equation 3*b*.

EXAMPLE: The journal of a 3-in. diameter bearing for an electric motor is specified as 3.000, +0.0000, −0.0005. How should the bronze bearing bore be specified to insure a satisfactory value of m?

From Fig. 8,

$(2C)_{max}$ for a 3-in. diameter is 0.0047 in.
$(2C)_{min}$ for a 3-in. diameter is 0.0030 in.

From Equation 4,

$$t_B + 0.0005 = 0.0047 - 0.0030$$
$$t_B = 0.0012 \text{ in.}$$

Nominal bearing bore diameter from Equation 3*b* is

$$(D_B)_{nom} = (2C)_{min} + D_{nom}$$
$$= 0.0030 + 3.0000$$
$$= 3.0030 \text{ in.}$$

Bore diameter may then be specified as

$$D_B = 3.0030^{+0.0012}_{-0.0000}$$

In this example, the tolerance assigned to both bearing members allows m to range between 1.0 and 1.5. Satisfactory results are obtained by using an average value for m. In this case, a value of 1.25 would be selected for m.

To maintain proper diametral clearance, the bore diameter of the bearing should be finish-machined to size after installation. This recommended practice eliminates errors caused by the accumulation of tolerances from bearing ID and OD and housing ID. The method also results, generally, in lower overall installation cost since only one close tolerance need be, and definitely can be, maintained.

Bearing Characteristic Number

First major step in the design of a bronze bearing is to evaluate the bearing characteristic number, A. This number is determined as follows:

$$A = \frac{m^2 W}{D^2 Z N} \quad (5)$$

Note that this number is a slight modification of the parameter ZN/p used previously. Usually, desired operating speed N and total steady load W to be carried are known. Likewise, journal diameter D in the vicinity of the bronze bearing may also be specified to meet certain stiffness or deflection requirements. Determination of clearance factor m was discussed in the preceding section, *Bearing Clearance Ratios*.

Since the operating temperature of the lubricant film for a bronze bearing of unknown length is impossible to predict, the next best thing is to assume an operating temperature. Absolute viscosity Z can then be determined for the lubricant at the assumed temperature, T_2. Ordinarily, sufficient data from the manufacturer of the selected lubricant will permit simple determination of a value for Z. If complete information is not available, absolute viscosity can be calculated by a method described in a later article. However obtained, the proper value of Z is then used in Equation 5.

A fair approximation of lubricant temperature rise may be made if the method of lubrication is known. For forced-feed or pressure lubrication, temperature rise $T_2 - T_1$ will be in the neighborhood of 5 to 10 F. With less oil being supplied, the bearing will tend to run hotter since it is not being flushed by as much relatively cool inlet oil. Thus, for other lubricating techniques, such as oil bath, splash feed, and oil ring, lubricant temperature rise may range from 10 to 100 F. Knowing these relationships, the designer should be able to make a reasonable approximation of the lubricant film temperature and, hence, of lubricant viscosity.

With known and determined values substituted for m, W, D, Z, and N in Equation 5, the bearing characteristic number can be evaluated. If A falls in the range between 0.0005 and 0.50, practical full-film lubrication is possible. With special care, the upper limit can easily be doubled to 1.0. However, most bronze sleeve bearings for rotating machinery operate within this given range of bearing characteristic number. If A is greater than 0.50, special types of lubrication discussed later may be required.

Even if the value of A falls within the normal

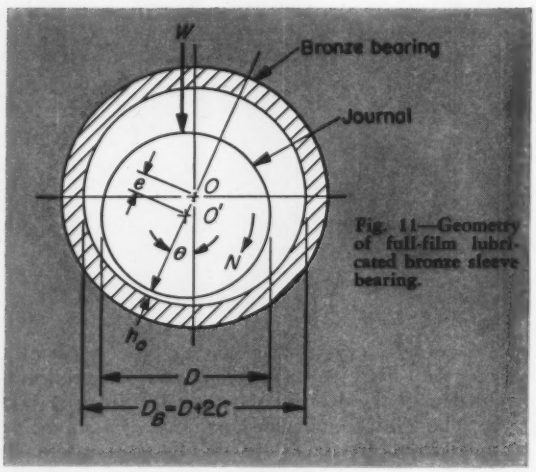
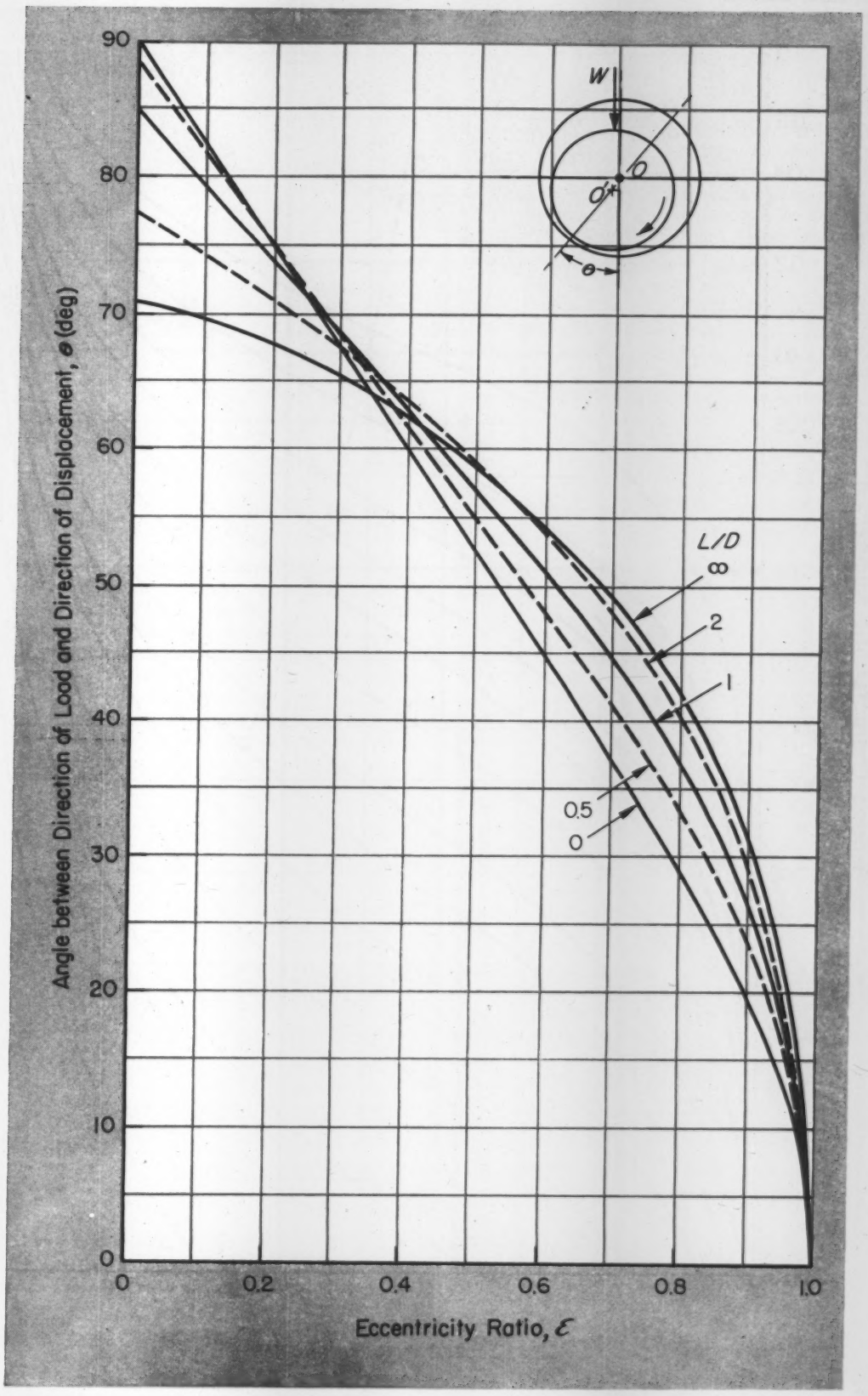
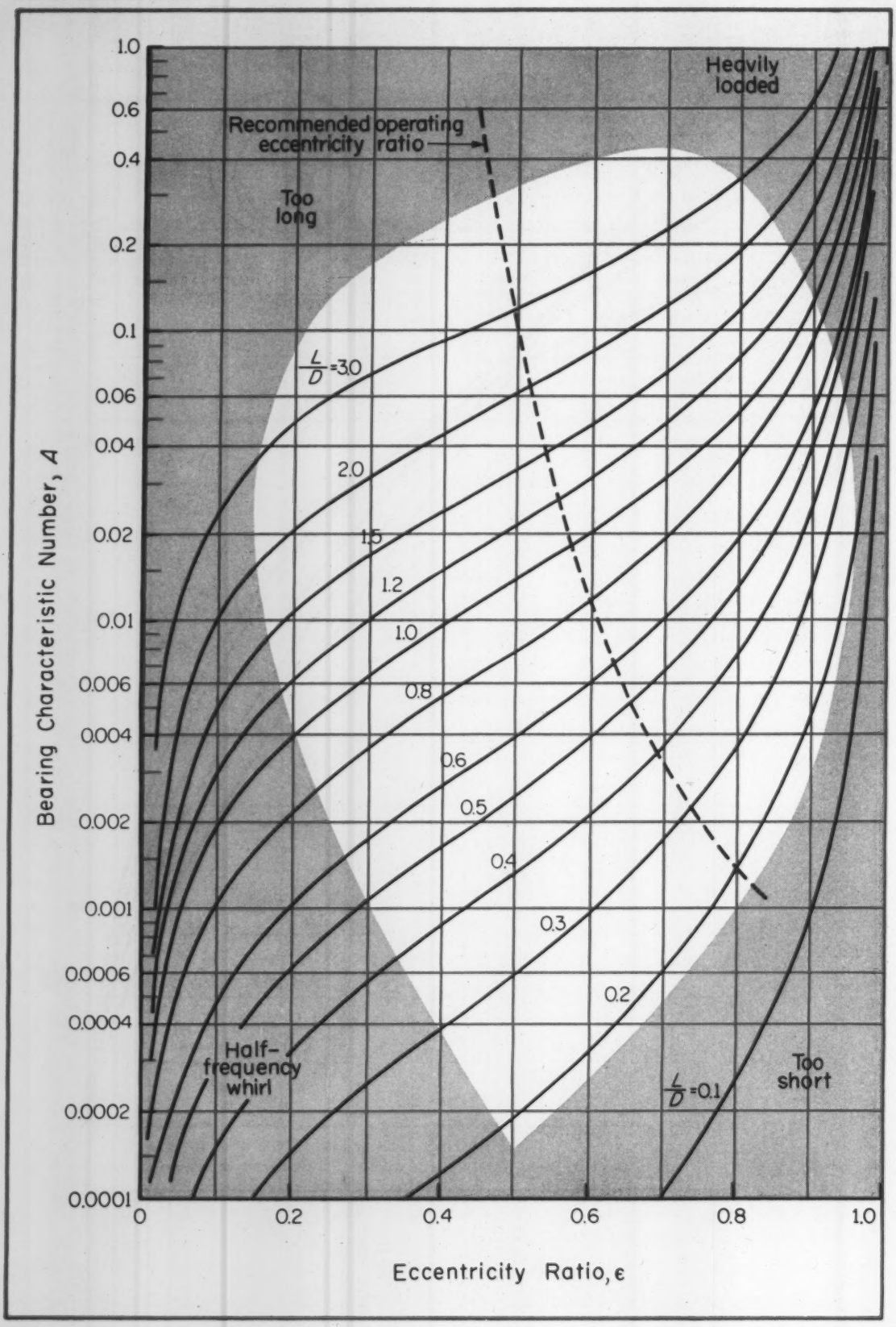


Fig. 11—Geometry of full-film lubricated bronze sleeve bearing.

Fig. 12—Angular location of displaced journal within a full-film lubricated bronze bearing.


Angle between Direction of Load and Direction of Displacement, ø (deg)
90
80
70
60
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1.0
Eccentricity Ratio, ε
W
O
O'
e
L/D
∞
2
1
0.5
0


Heavily loaded
Recommended operating eccentricity ratio
Too long
L/D=3.0
2.0
1.5
1.2
1.0
0.8
0.6
0.5
0.4
0.3
0.2
L/D=0.1
Too short
Half-frequency whirl
Bearing Characteristic Number, A
Eccentricity Ratio, ε
1.0
0.6
0.4
0.2
0.1
0.06
0.04
0.02
0.01
0.006
0.004
0.002
0.001
0.0006
0.0004
0.0002
0.0001
0
0.2
0.4
0.6
0.8
1.0

range, full-film lubrication may not be possible for one or more of the following reasons:

1. Insufficient flow of lubricant to the bearing as a result of either ignorance or an attempt to reduce the flow to a value felt to be acceptable.
2. Misplaced oil-feed grooves.
3. Too low a lubricant viscosity.
4. Use of a porous bearing material which prevents formation of hydrodynamic pressures. Hence, separation of the journal from the bearing is not possible.
5. Severe misalignment.
6. Dirty lubricant.
7. Excessive heating within the bearing which is a result of poor heat dissipation and which reduces lubricant viscosity. Cast bronze bearings have excellent heat-dissipation qualities.

A large value for bearing characteristic number indicates a heavily loaded or relatively slow-speed bearing. Conversely, light loads and high speeds give very low bearing characteristic numbers. If desired, the numerical value of A can be adjusted up or down by varying the parameters m, D, and Z. Also, duty cycle of the bearing should be investigated to determine the possible variation of A with changing speed, load, and, indirectly, viscosity.

Bear in mind that only steady loads in both magnitude and direction are considered for use in the bearing characteristic number. Likewise, only constant, unidirectional rotation of the shaft is applicable for continual full-film, hydrodynamic lubrication. Shock loads, rotating loads, and reciprocating or oscillating journals are considered in another section of this Manual. This treatment is valid only for fluid lubricants and does not apply to grease lubrication.

Journal Eccentricity Ratio

An important concept in full-film lubrication is journal eccentricity ratio, ε, which is determined from

$$\varepsilon = \frac{e}{C} \tag{6}$$

Fig. 11 illustrates the eccentricity of a bronze bearing operating with a full film of lubricant. In this cross section of the bearing, clearance has been purposely exaggerated. Equilibrium position for the center of the journal, O', will be displaced from the center of the bearing, O, a distance equal to e and at an angle equal to θ. Both e and θ depend upon:

1. Magnitude and direction of load W.
2. Magnitude and direction of speed N.
3. Viscosity of lubricant in the film, Z.
4. Bearing clearance factor m.

When there is no load on the bearing ($W = 0$), the journal will run virtually centered within the bearing, and eccentricity e will be zero. Thus, from Equation 6, the eccentricity ratio will likewise be zero. As the load increases, the journal moves eccentrically until a position is reached where hydrodynamic pressure distribution developed in the oil film balances the load. Additional loading requires that the journal move to an even more eccentric position.

While eccentricity e is increasing, minimum film thickness h_o is decreasing. The equation for h_o is

$$h_o = C - e = C(1 - \varepsilon) \tag{7}$$

If the load becomes great enough, the journal may eventually touch the bearing. For this situation, $e = C$, $h_o = 0$, and the eccentricity ratio becomes unity. Fig. 12 is a plot of angle θ (between direction of load and direction of displacement of the journal) and eccentricity ratio ε for various L/D ratios. Thus, for any eccentricity ratio, the exact location of the center of the journal and also the location and magnitude of minimum film thickness can be readily determined. This information is necessary for later considerations such as surface-finish requirements and oil grooving.

Fig. 13—Bearing size selection chart for full-film lubricated 360-deg bronze sleeve bearings.

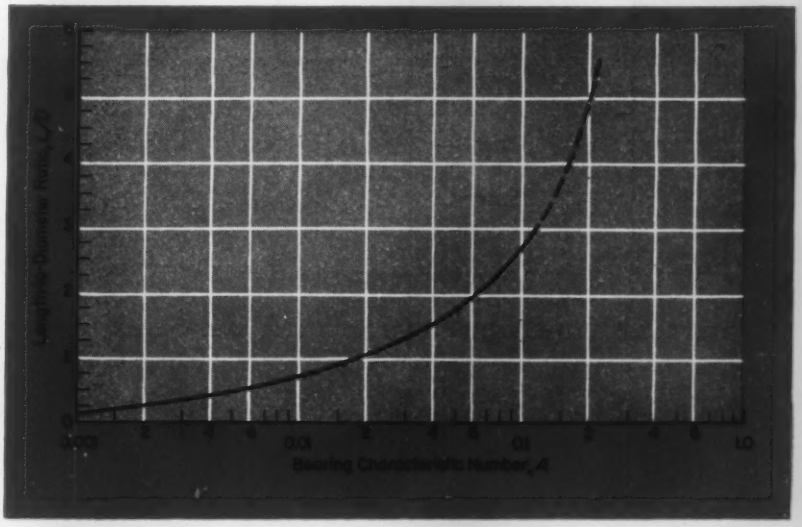
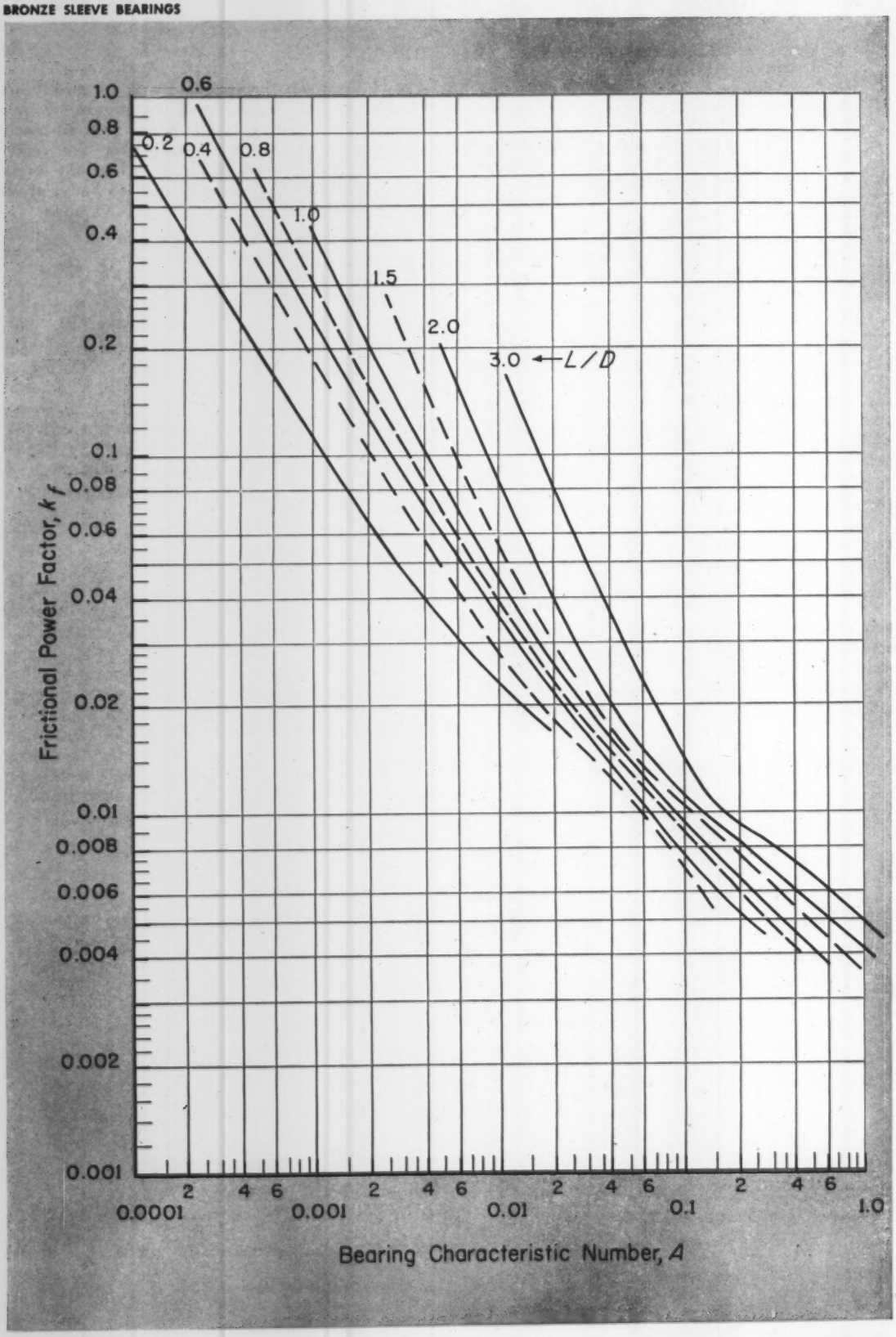


Fig. 14—Ratios of L/D required by recommended operating eccentricity ratios. The L/D curve is obtained from Fig. 13.


0.6
0.2
0.4
0.8
1.0
1.5
2.0
3.0 ← L/D
1.0
0.8
0.6
0.4
0.2
0.1
0.08
0.06
0.04
0.02
0.01
0.008
0.006
0.004
0.002
0.001
Frictional Power Factor, k_f
2 4 6 2 4 6 2 4 6 2 4 6
0.0001
0.001
0.01
0.1
1.0
Bearing Characteristic Number, A

Bearing Length

Once the bearing characteristic number is computed, a suitable length for the bearing can be established which will insure satisfactory full-film performance. Fig. 13 permits determination of proper bearing proportions L/D and thereby calculation of L since D is known.

In Fig. 13 eccentricity ratio is plotted against bearing characteristic number for various L/D ratios. The unshaded area of the chart is the only region of interest. To use this chart, enter the vertical axis at the proper value of A and move horizontally across the graph to the dashed line marked *Recommended operating eccentricity ratio.* The required ratio of L/D to obtain this recommended eccentricity ratio for the particular value of A is obtained by interpolation of the L/D curves. As an example, suppose the computed bearing characteristic A equals 0.011. From the chart, this value of A gives L/D equal to 0.80 for the recommended operating eccentricity ratio of 0.60. Since D is known, L is easily calculated. Fig. 14 is a plot of L/D versus A for recommended operating eccentricity ratios.

Lengths of bronze bearings other than those dictated by the recommended operating eccentricity ratio can be used. For instance, for the case just mentioned where $A = 0.011$, an L/D value as low as 0.2 could be chosen, but the operating eccentricity ratio would be 0.95, which means that the journal would almost be touching the bearing. At the other extreme, L/D ratio of 1.7 gives an operating eccentricity ratio of 0.15, which means that the journal would be only slightly displaced within the bearing.

Any selection of L/D within the unshaded area of Fig. 13 can be made. Shorter bronze bearings are usually preferred from the standpoint of space, friction, and flow requirements. However, for the same bearing characteristic number, shorter bearings necessarily operate with greater eccentricity. There must be a compromise, and on this basis the recommended operating eccentricity ratio curve in Fig. 13 was established. Also, some allowance is made to enable the bearing to carry higher loads than anticipated, since operating film thicknesses are still fairly large. In addition, if film thicknesses are large, slight contamination of the lubricant can be tolerated. Thus, if possible, bearing lengths for full-film lubrication should be computed as dictated by the recommended operating eccentricity ratios. Fig. 14 makes this computation very easy once the value of A has been calculated.

For the hypothetical value of $A = 0.011$, which gives an L/D ratio of 0.8, the curve of $L/D = 0.8$ can be followed to observe the change of eccentricity ratio caused by a change in load and/or speed and/or viscosity. For instance, if the load doubles, the new value of A will be 0.022. According to Fig. 13, this value requires an eccentricity ratio of 0.73. In other words, once an L/D ratio has been decided upon, location of the journal within the bearing can be completely defined, with the help of Fig. 12 and 13, for varying speed, load, or viscosity.

Power Requirements

Although the coefficient of friction for full-film lubricated bronze bearings is quite small, power required to drive the journal may be appreciable because of high load-carrying capacity and reasonably high speeds. Also, since frictional energy is dissipated in the form of heat, energy required to overcome friction must be evaluated to determine any cooling requirements for the bearing.

The equation which determines driving or input power is

$$P_F = k_f m D N W \times 10^{-6} \qquad (8)$$

The value of frictional power factor k_f can be obtained from Fig. 15 if the value of the bearing characteristic number and the L/D ratio are known.

Fig. 15—Frictional power factors for 360-deg full-film lubricated bronze bearings having various L/D ratios.

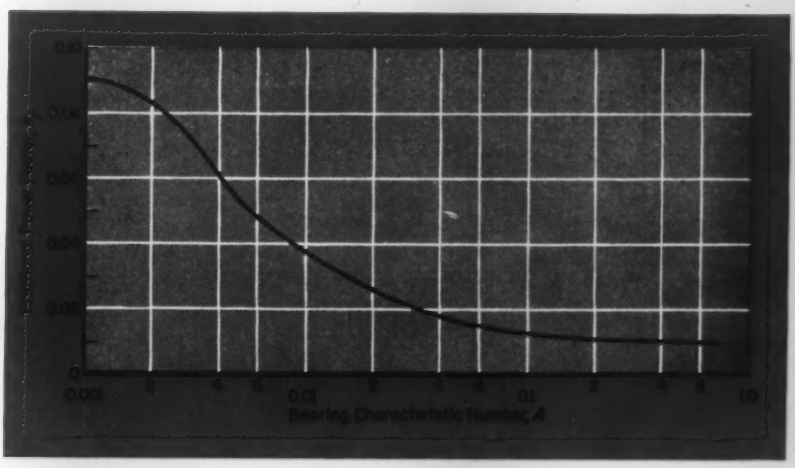
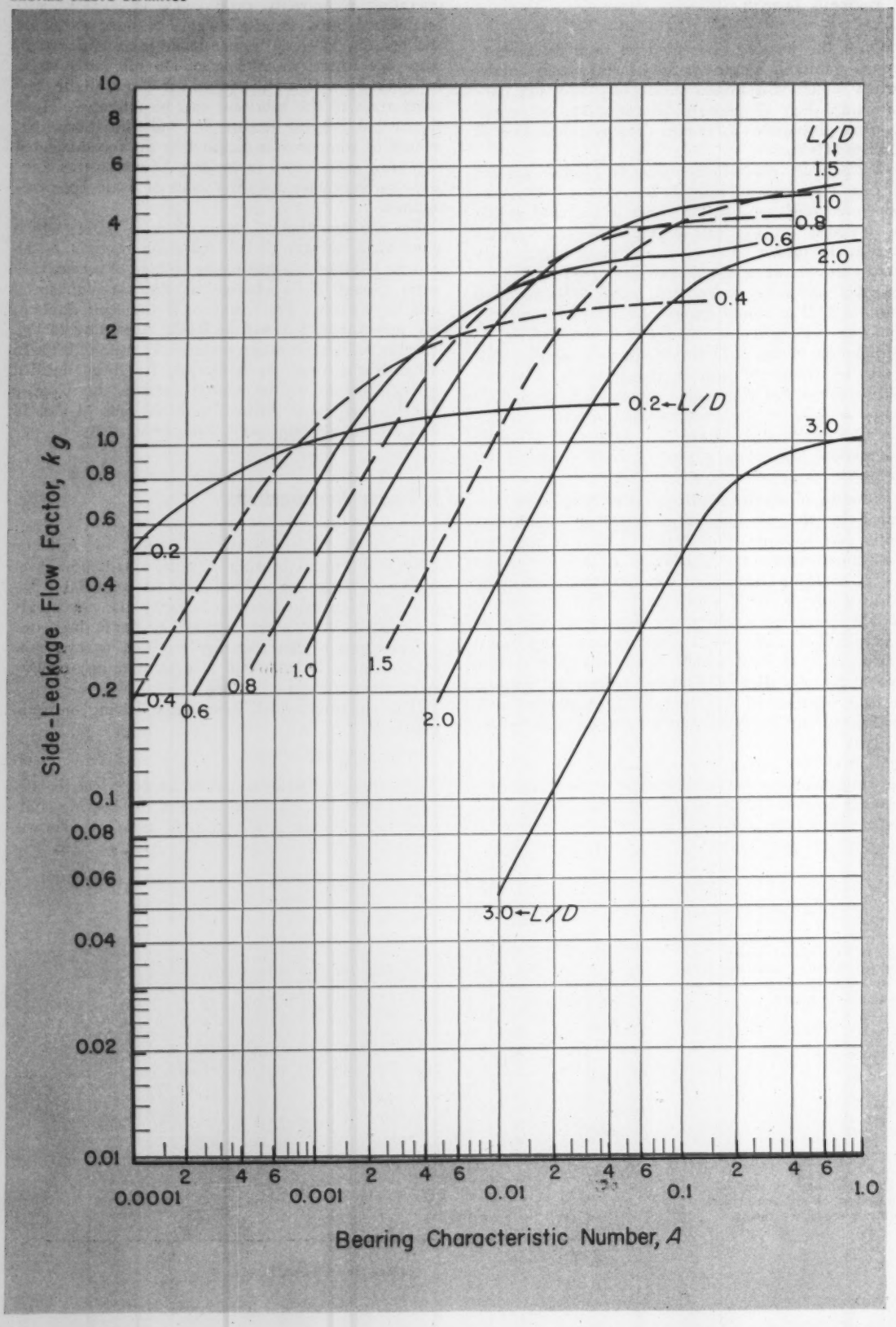


Fig. 16—Frictional power factors based upon recommended operating eccentricity ratios.


Side-Leakage Flow Factor, kg
Bearing Characteristic Number, A
L/D
1.5
1.0
0.8
0.6
2.0
0.4
0.2←L/D
3.0
0.2
0.4
0.6
0.8
1.0
1.5
2.0
3.0←L/D
10
8
6
4
2
1.0
0.8
0.6
0.4
0.2
0.1
0.08
0.06
0.04
0.02
0.01
0.0001
0.001
0.01
0.1
1.0

To illustrate with the previous example where A = 0.011 and the L/D ratio is 0.80, Fig. 15 gives k_f = 0.036. Since the other terms in Equation 8 are known, the horsepower requirement for a full-film bronze sleeve bearing can be easily computed.

For a bearing of given L/D ratio, the variations in power requirement with change in load, speed, or viscosity can be determined, for a correspondingly different value of A, by picking from Fig. 15 the new value of k_f and substituting it into Equation 8. In the preceding section, *Bearing Length*, particular values of A were shown to have a recommended operating eccentricity ratio which, if adhered to, fixed the L/D ratio. If both A and ratio L/D are fixed, k_f is restricted to a single value also. Thus, a plot of k_f against A can be obtained based on a bearing designed to operate at the recommended operating eccentricity ratio. Such a plot is shown in Fig. 16.

Oil-Feed Requirements

In a 360-deg bronze bearing, oil must enter the bearing at the same rate that it escapes from the ends of the bearing. End leakage in a sleeve bearing is caused by the high pressure that develops in the center of the bearing. This pressure forces lubricant toward the low-pressure areas at the ends of the bearing (see Fig. 4). If the journal is to maintain its position within the bearing, lubricant lost through end leakage must be continually replenished.

The theoretical oil-feed rate required to maintain the clearance space filled with oil while the bearing is operating is

$$Q = k_q m D^3 N \times 10^{-6} \qquad (9)$$

The value of side-leakage flow factor k_q can be obtained from Fig. 17. For given values of A and L/D, k_q can be quickly determined. For the example using A = 0.011 and L/D = 0.8, k_q is found to equal 2.8. As in similar charts, curves in Fig. 17 for given values of L/D indicate the variation of k_q with changes in load, speed, and viscosity. When these values of k_q are used in Equation 9, the variations in flow requirement can be determined.

Surprisingly enough, if less than the computed rate of flow is delivered, operating eccentricity will be not far removed from what it would be if the required rate were delivered. The effect of reduced oil flow on operating eccentricity is almost negligible at the higher eccentricity ratios. How much less the oil-feed rate may safely be than the value calculated with k_q in Equation 9, while maintaining reasonably similar eccentricity ratios, is difficult to specify.

As a rule of thumb, when operating at eccentricity ratios less than 0.50, calculated oil-feed rate should be maintained if the expected operating eccentricity ratio is to be realized. For larger eccentricity ratios, feed rate may be somewhat less than calculated, gradually decreasing to about 80 per cent of the calculated flow at approximately 0.90 eccentricity ratio.

Consider the operation of a bronze bearing subjected to wide extremes of load. If enough oil is supplied to the bearing at high loads, the bearing will be oversupplied at low loads, which is not harmful. However, if the flow rate is designed for low loads, insufficient oil flow for high loads will force the bearing to operate on a thinner film of lubricant. Hence, the safe practice is to supply the highest oil-feed rate required to meet varying conditions.

If A and L/D are fixed, k_q must also be restricted to a particular value. For a bearing designed to operate at the recommended operating eccentricity ratio, k_q can be plotted against A as shown in Fig. 18.

Minimum Flow Requirements

Operating with a bearing characteristic number that indicates a full film of lubricant between journal

Fig. 17—Side-leakage flow factors for 360-deg full-film lubricated bronze bearings having various L/D ratios.

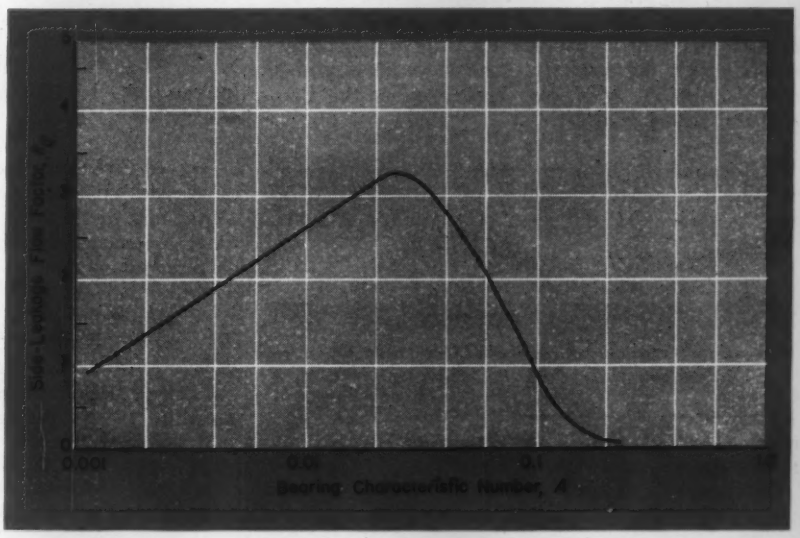


Fig. 18—Side-leakage flow factors based upon recommended operating eccentricity ratios.

and bearing, a bronze bearing will run at a prescribed eccentricity if supplied with sufficient lubricant. If the rate of flow to the bearing is reduced, the journal will move to a new, more eccentric position within the bearing because of insufficient fluid. Experiments have determined that fluid-film lubrication is not possible below a definite minimum lubricant flow rate.[1] The journal will begin to touch the bearing at the point of closest approach, and bearing friction will increase markedly if lubricant flow is below this minimum value.

Minimum flow required for full-film lubrication, Q', can be determined approximately with the following equations:

$$Q' = 29.3 \times 10^{-9} \left(L + 0.0043 \frac{W}{D} \right) mD^2N, \text{ gpm} \quad (10a)$$

$$Q' = 3.32 \times 10^{-3} \left(L + 0.0043 \frac{W}{D} \right) mD^2N, \text{ drops per min} \quad (10b)$$

1 cu cm = 30 drops

Needless to say, supplying just the barest minimum of flow to the bearing to sustain full-film lubrication, especially in a new bearing which has had no "wearing in," is extremely dangerous practice. However, Q' can be used as a guide to determine what value the flow may be allowed to approach and still maintain the benefits of full-film lubrication.

Oil-Film Temperature

To determine lubricant viscosity and, in turn, bearing characteristic number, oil film temperature T_2 had to be assumed. Since means for calculating bearing length, frictional power, and flow through the bearing have been presented, temperature rise of the lubricant as it passes through the bearing can now be computed. A portion of the heat generated in the bearing is transmitted to the flowing lubricant, and some of the heat is also dissipated through the wall of the bearing to the ambient atmosphere. Of the many types of sleeve bearing materials available, solid cast bronze offers the best heat-dissipating qualities.

Self-Contained Bearing System: A self-contained bearing is one which requires no oil-circulating or cooling system. In this type of bearing practically all the heat is removed by conduction, convection, and radiation to the surrounding atmosphere. Self-contained bearings are the conventional pillow-block and pedestal type found on most motors, generators, turbines, pumps, and similar equipment. Such bearings reach thermal equilibrium 1 to 3 hr after starting. Thereafter, radiation and convection from the bearing housing is sufficient to dissipate all the heat generated by friction in the bearing.

If the particular bearing is operating at high speeds and heavy loads, equilibrium may be reached at a high level of temperature—perhaps higher than 200 F. Temperatures in this range may not be acceptable for industrial use because some lubricants undergo a rather rapid deterioration which results in the formation of harmful acids. Therefore, the limit of acceptable equilibrium film temperatures for the usual industrial application range from 160 to 180 F. Operation beyond these temperatures usually requires auxiliary cooling such as a cooling coil in the oil sump. In this case, some of the heat is then removed directly from the oil itself.

Cast-bronze bearings can be effectively applied at elevated temperatures with the use of proper high-temperature lubricants. However, discussion in this Manual is concerned with bronze bearing operation at less than 200 F.

In a self-contained bearing system the assumption that all frictional heat generated with the bearing must be dissipated to the ambient atmosphere permits the resulting temperature difference to be expressed as[2]

$$T_2 - T_4 = \frac{(s + 1)P_F}{15 \times 10^{-6} DLK_1} \quad (11)$$

Values for s and K_1 are simplifications of data in Fuller's text and may be obtained from Table 1.

The value of T_2 can be determined from Equation 11 and compared with the assumed value used earlier to calculate the bearing characteristic number. In all likelihood they will not agree exactly. Hence, another assumption of T_2 is made and the entire process repeated. Another value of T_2 is calculated and is again compared with the assumed value. This process is continued until reasonable agreement is obtained between the assumed value of T_2 and the calculated value of T_2. The actual process will be illustrated in the sample problem which follows later.

Forced-Feed Lubricating System: In bearings supplied with copious amounts of relatively cool lubricant, most of the heat of friction enters the oil and is thus removed from the bearing. Usually, the oil is returned to a sump where it is cooled before reentering the bearing.

If the assumption is made that all heat generated by friction within the bearing is removed by the lubricant and that side-leakage flow through the bearing is as determined by Equation 9, then temperature rise of the lubricant can be expressed as

$$T_2 - T_1 = \frac{42.4\, P_F}{\gamma c_p Q} \quad (12)$$

If oil inlet temperature T_1 is known, T_2 can readily

[1]References are tabulated at end of article.

Ambient Air Condition	Ventilation Factor, K_1	Lubrication Factor, s — Oil-Bath Lubrication	Oil-Ring Lubrication	Waste-Pack Lubrication
Quiet Air	6	0.20	0.90	1.60
Moving Air (500 fpm)	16	0.63	1.30	4.4

be determined from Equation 12 and compared with the assumed value of T_2 used to determine the bearing characteristic number. Reasonable agreement indicates a solution has been found. Otherwise, the process, based on a new assumed value for T_2, is repeated until agreement between assumed and calculated values of T_2 is obtained.

Combined Heat Loss: For those cases where heat is removed not only by the oil but also by conduction through the bearing, lubricant film temperature can be determined by the following equation, which is a combination of Equations 11 and 12:

$$T_2 = \frac{P_F + \left(\frac{15 \times 10^{-6} K_1}{s+1}\right) T_4 + \left(\frac{\gamma c_p Q}{42.4}\right) T_1}{\frac{15 \times 10^{-6} K_1}{s+1} + \frac{\gamma c_p Q}{42.4}},$$

degrees Rankine (13)

Since this equation does not deal with temperature differences, absolute temperatures in degrees Rankine (degrees F plus 460) must be used for T_1, T_2, and T_4.

Once again, if T_2 as computed from Equation 13 is different than the assumed value, a new assumption for T_2 is made and all the calculations repeated until agreement is reached. Equation 13 should be used when there is any doubt concerning the distribution of heat losses.

Simplified Design Method

To make the computational work required for actual bearing design more systematic, Table 2 is presented in three parts. Necessary entries and computations are indicated, and space is provided for given or determined values. Part *A* lists data needed to design the bearing. This information is usually given or known. Part *B* provides for preliminary calculations that reduce the number of terms involved and simplify final computations. Values for all symbols used are obtained from Part *A*. Part *C* is a step-by-step process for final calculations which determine a temperature balance.[3] Results obtained from Step 10 indicate whether or not the bearing design is satisfactory, and if not, what adjustment is necessary before again proceeding through the ten steps.

Heavily Loaded Bronze Bearings

A heavily loaded bronze bearing operating under full-film lubrication will have a high eccentricity ratio. Hence, resulting minimum film thickness h_o will be extremely small. The heavily loaded, or relatively slow-speed, region of operation is indicated as the extreme upper right portion of Fig. 13.

Theoretically, a bronze bearing will carry an infinitely large load before the journal touches the bearing. However, the actual maximum load that a sleeve bearing can support is far short of infinite because of such things as surface roughness, journal deflection, bearing distortion, and out-of-roundness. Recommended maximum allowable eccentricity ratios for heavily loaded bronze bearings of various L/D ratios are shown on Fig. 13. If these values are exceeded, the journal may rupture the film of lubricant and touch the bearing.

When such contact does occur, friction within the bearing increases very markedly. Frictional increases of 1000 per cent are not uncommon for slight increases in load, or decreases in speed, in the transition from full-film to mixed-film lubrication. The increased friction generates more heat, which reduces lubricant viscosity, which promotes more metal-to-metal contact, which causes more friction, and the cycle is repeated again and again. If overloading is not too severe, this vicious cycle will continue until the bearing "wears-in" and some temperature equilibrium condition is established in the sleeve bearing.

On the other hand, operation of the bearing under severe overload can lead to rapid temperature rises, accelerated wear, and early failure. Thus, if a sleeve bearing is to be subjected to unavoidable overloading, the overloads should be of short duration and should occur no oftener than absolutely necessary. Also, if possible, the bearing should be well worn-in before being overloaded. The beneficial effects of wearing-in result from smoothing microscopic high spots.

If continuous operation is desired at speeds and steady loads requiring a bearing characteristic number greater than 0.50, full-film hydrodynamic operation should be abandoned in favor of hydrostatic lubrication. This method of lubrication is discussed later.

Reviewing briefly, operation beyond the maximum eccentricity ratios shown in Fig. 13 is to be avoided if at all possible. Occasionally, the bearing may be subjected to overloads that are not too severe and of short duration. For this type of service the bearing should be carefully worn-in before being overloaded. In any case, a maximum allowable bearing characteristic number is approximately 0.50 for steady (nonshock) loading.

Shock-Loaded Bronze Bearings

In many applications, bronze sleeve bearings under full-film lubrication are subjected to pulsating or reciprocating loads. Because of high pressure and lack of continuous sliding or rotation, oil-film breakdown and severe wear should theoretically occur if the bearing characteristic number is used as a criterion. Strangely enough, bronze bearings properly designed for applications of this type show no signs of wear. Crank-pin and piston-pin bearings are examples of heavily loaded, slow-speed bronze bearings having varying loads. Relative motion in such bearings is zero at periodic intervals, but nevertheless, an oil film is maintained between bearing surfaces.

This load-carrying phenomenon can be explained by the fact that a viscous lubricant cannot be instantaneously squeezed out from between two sur-

Table 2 — Design Sheet for Full-

Part A--Known Data

	Symbol	Value	Units
Total steady load	W	—	lb
Journal speed	N	—	rpm
Journal diameter	D	—	in.
Clearance factor	m	—	---
Oil inlet temperature	T_1	—	F
	T_1	—	Rankine
Ambient atmosphere temperature	T_4	—	F
	T_4	—	Rankine
Radial clearance	C	—	in.
Ventilation factor	K_1	—	---
Lubrication factor	s	—	---
Lubricant density	γ	—	lb/gal
Lubricant specific heat	c_p	—	Btu/lb-deg F
Dead weight supported	W_m	—	lb

Part B--Simplified Factors

	Calculation	Value
k_1	m^2W/D^2N	—
k_2	$mDNW\times10^{-6}$	—
k_3	$mD^3N\times10^{-6}$	—
k_4	$(15\times10^{-6}K_1)/(s+1)$	—
k_5	$\gamma c_p/42.4$	—

Part C--Final Calculation Form

Step NO.		Values for First Assumption	Values for Second Assumption	Values for Third Assumption
1.	T_2(assumed), deg Rankine	—	—	—
2.	Z(known), centipoise	—	—	—
3.	$A=k_1/Z$	—	—	—
4.	L (Fig. 13), in.	—	—	—
5.	ϵ (Fig. 13)	—	—	—
6.	h_o (Equation 7), in.	—	—	—
7.	θ (Fig. 12), deg	—	—	—
8.	$P_F=k_f k_2$, hp	—	—	—
9.	$Q=k_Q k_3$, gpm	—	—	—
10.	$T_2=P_F+k_4T_4+k_5Q\,T_1)/(k_4+k_5Q)$, deg Rankine	—	—	—

Film Lubricated Bronze Bearings

Preliminary Steps

Part A: Fill in values dictated by the problem.

Select m from Fig. 6 through 10 for the specified class of machinery and operating speed.

Obtain K_1 and s from Table 1.

Values of γ and c_p should be known. Average values for normal petroleum lubricants are $\gamma = 7.5$ lb/gal and $c_p = 0.48$ Btu/lb-deg F.

Part B: Make calculations indicated, obtaining necessary values from Part *A*, and record the answers.

Final Calculations

Step 1. Choose a suitable value for T_2. Temperature T_2 should not be so high as to weaken the bearing material or damage the lubricant.

Step 2. Determine Z for assumed temperature T_2.

Step 3. Calculate A by dividing factor k_1 from Part *B* by Z from Step 2.

Step 4. Obtain L/D ratio from Fig. 13 using the curve for recommended operating eccentricity ratio and the value of A in Step 3. Then, calculate L by multiplying the L/D ratio times D from Part *A*.

Step 5. Obtain ε from Fig. 13 for value of A in Step 3 and the curve for recommended operating eccentricity ratio.

Step 6. Solve Equation 7 for h_o using C from Part *A* and ε from Step 5.

Step 7. Obtain angle θ from Fig. 12 for ε of Step 5 and the L/D ratio obtained for Step 4.

Step 8. Obtain k_f from Fig. 15 for value of A in Step 3 and the L/D ratio obtained for Step 4. Then, calculate P_F by multiplying k_f times factor k_2 from Part *B*.

Step 9. Obtain k_q from Fig. 17 for value of A in Step 3 and the L/D ratio obtained for Step 4. Then, calculate Q by multiplying k_q times factor k_3 from Part *B*.

Step 10. Calculate T_2 with the formula in the table. Use factors k_4 and k_5 from Part *B*, temperatures T_1 and T_2 from Part *A*, frictional horsepower P_F from Step 8, and oil-flow rate Q from Step 9. If the value of T_2 calculated in Step 10 does not agree with the assumed value in Step 1, another value is assumed for T_2 and the process in Part *C* repeated until agreement is obtained.

Numerical Example

Design a cast-bronze sleeve bearing for a precision spindle operating with full-film lubrication. A well-ventilated, oil-bath lubricating system with SAE 20 motor oil is to be used.

Known values for the Design Sheet, Part *A*, are: $W = 500$ lb; $N = 1000$ rpm; $D = 1.5$ in.; $m = 1.025$ from Fig. 6; $T_1 = 130$ F $= 590$ Rankine; $T_4 = 100$ F $= 560$ Rankine; $C = 0.8 \times 10^{-3}$ in.; $K_1 = 16$ from Table 1; $s = 0.63$ from Table 1; $\gamma = 7.5$ lb per gal; $c_p = 0.48$ Btu/lb-deg F; $W_m = 2$ lb.

Calculations for Part *B* are: $k_1 = (1.025)^2(500)/(1.5)^2(1000) = 0.234$; $k_2 = 1.025\ (1.5)(1000)(500)(10^{-6}) = 0.768$; $k_3 = 1.025\ (1.5)^3(1000)(10^{-6}) = 3.46 \times 10^{-3}$; $k_4 = 15 \times 10^{-6}\ (16)/(0.63 + 1) = 0.147 \times 10^{-3}$; $k_5 = 7.5\ (0.48)/42.4 = 0.085$.

Values for the complete design are tabulated for Part *C*.

Explanation: First entry for Step 1 in the table for Part *C* is an assumed value for T_2. Since the bearing will be oil-bath lubricated, a reasonable temperature rise would be 10 F, or $T_2 = T_1 + 10 = 140$ F, or $T_2 = 600$ Rankine.

First entry for Step 2 is obtained from the manufacturer of the SAE 20 oil for T_2 in Step 1. A later article illustrates how Z can also be determined if complete lubricant information is not available from the manufacturer.

First entry for Step 3 is $0.234/25 = 0.0094$.

For Step 4, the L/D ratio is obtained from Fig. 13 for the value of A in Step 3 and the curve for recommended operating eccentricity ratio. This L/D value is noted in the table. Length is then $0.7\ (1.5) = 1.05$.

First entry for Step 5 is obtained from Fig. 13 for the value of A in Step 3 and the curve for recommended operating eccentricity ratio.

First entry for Step 6, calculated from Equation 7, is $0.8 \times 10^{-3}\ (1 - 0.62) = 0.304 \times 10^{-3}$. This is an acceptable minimum film thickness.

First entry for Step 7 is obtained from Fig. 12 for the L/D ratio noted in Step 4 and the value of ε in Step 5.

For Step 8, k_f is obtained from Fig. 15 for the value of A in Step 3 and the L/D ratio noted in Step 4. Frictional horsepower is then $0.040\ (0.768) = 0.0307$.

For Step 9, k_q is obtained from Fig. 17 for the value of A in Step 3 and the L/D ratio noted in Step 4. Oil-flow rate is then $2.60\ (3.46 \times 10^{-3}) = 9.00 \times 10^{-3}$.

First entry for Step 10, calculated from the equation in Part *C*, Table 2, is $(0.0307 + 0.147 \times 10^{-3} \times 560 + 0.085 \times 9.00 \times 10^{-3} \times 590)/(0.147 \times 10^{-3} + 0.085 \times 9.000 \times 10^{-3}) = 619$.

Since this value for T_2 does not agree with the assumed value in Step 1, a new assumption must be made. The second assumption, $T_2 = 615$ Rankine, is entered for Step 1. Proceeding through the calculations as just described gives a calculated value of 611 Rankine for Step 10. A third assumption is made and the calculated value of 612 Rankine matches the assumed value of T_2. Hence, the third cycle represents a solution, and the results obtained for the other values are valid.

Bearing bore diameter D_B will be $D + 2C = 1.5 + 2\ (0.8 \times 10^{-3}) = 1.5016$ in.

Center of the operating journal, from Equation 6, will be distance e from center of the bearing: $e = 0.60\ (0.8 \times 10^{-3}) = 0.48 \times 10^{-3}$ in.

Theoretical oil-flow rate that will support the journal in its calculated position is 0.00986 gpm, or 1120 drops per min. Minimum oil-flow rate for full-film lubrication, from Equation 10*b*, is $Q' = 3.32 \times 10^{-3}\ (1.20 + 0.0043 \times 500/1.5)\ (1.025)\ (1.5)^2(1000) = 20.2$ drops per min.

Thus, if the oil supply rate is reduced to approximately 20 drops per min, full-film lubrication may still be possible. However, the journal will nearly be touching the bearing, and T_2 will be much larger than the assumed value of 612 Rankine because, in this problem, lubricant is used to remove most of the frictional heat generated within the bearing. As oil-flow decreases, the bearing runs hotter. Increased operating temperature will decrease the absolute viscosity of the lubricant, which, in turn, will cause the journal to operate more eccentrically. Likewise, if oil-flow is reduced to a low rate, sufficient lubricant may not be available within the bearing to fill the clearance volume. Hence, the journal must operate more eccentrically.

Step No.		First Assumption	Second Assumption	Third Assumption
1.	T_2	600	615	612
2.	Z	25	18.3	19.5
3.	A	0.0094 ($L/D = 0.7$)	0.0128 ($L/D = 0.85$)	0.0120 ($L/D = 0.80$)
4.	L	1.05	1.275	1.20
5.	ε	0.62	0.60	0.60
6.	h_o	0.304×10^{-3}	0.32×10^{-3}	0.32×10^{-3}
7.	θ	48	50	50
8.	P_F	0.0307	0.0253	0.0261
9.	Q	9.00×10^{-3}	10.03×10^{-3}	9.86×10^{-3}
10.	T_2	619	611	612

faces that are approaching each other. Time is required for the load to force these surfaces to meet. During that interval, a pressure is developed because the lubricant resists extrusion, and the load is actually supported by the oil film. Thus, if the load is of short enough duration, such as a shock load or a rotating load, the two surfaces will not meet before the load is removed. When the load is removed or reversed, the oil film can often recover its thickness in time for the next load application if the bearing is designed to permit and assist this buildup. However, indiscriminate location of oil holes, oil grooves, and reliefs may interfere with restoration of the oil film and thus destroy the major portion of the load-carrying capacity of the bearing.

The name used to describe this type of lubrication is "squeeze film." Requirements for successful squeeze-film lubrication are:

1. Copious amounts of lubricant with sufficient viscosity to resist being squeezed out of the clearance space.
2. Short duration of shock loads to avoid metal-to-metal contact. A reciprocating load or rotating load fulfills this requirement.
3. Absence of oil grooves or holes in the load-carrying region to avoid reducing the squeeze-film pressure developed.
4. Bearing materials which readily conform to shock loads without deforming, thus distributing load and squeeze film over a greater area. Cast bronze is an ideal material for this type of application.

Development of a squeeze film does not depend on rotational speed, and hence squeeze films may be used to good advantage when there is no relative sliding velocity.

Design of a bronze bearing which requires squeeze-film lubrication, because of slow (or zero) relative speed or extremely large loads, can be attempted if magnitude of load W_s and its duration, Δt, are known. Both these quantities are assumed to be constant. If load varies, as it would for a rotating load, some average load magnitude and time must be determined. With duration and magnitude of load known, the required length of bronze bearing may be determined with

$$L = \frac{(\Delta t) m^2 W_s}{k_s D Z} \qquad (14)$$

Shock-load factor k_s depends upon lubricant film thickness both before and at the end of the shock load. Fig. 19 shows values for k_s as determined by journal eccentricity ratio before the shock load, ε_o, and journal eccentricity ratio at the end of the shock load, ε_1. Use of Fig. 19 is illustrated for a journal that operates with an initial eccentricity ratio of $\varepsilon_o = 0$ and is required to have an eccentricity ratio of 0.60 at the end of the shock load. Enter the graph along the bottom at $\varepsilon_1 = 0.60$ and move up until curve $\varepsilon_o = 0$ is intersected. Then move horizontally to the k_s scale and read 1.43. With k_s and the magnitude and duration of shock load known, the required length of bearing can be computed using Equation 14.

Curves in Fig. 19 can also indicate whether or not a given bearing will carry a given shock load.

EXAMPLE: A bronze bearing with 1 in. diam, 1 in. length, and $m = 1.0$ operates at a speed of 1000 rpm with a steady load of 100 lb and a lubricant viscosity of $Z = 10$ centipoise. Determine lubricant film thickness at the end of a shock load of 500 lb applied in addition to the steady load for 0.05 second.

First, calculate the bearing characteristic number:

$$A = \frac{(1)^2(100)}{(1)^2(10)(1000)} = 0.01$$

From Fig. 13, for $L/D = 1.0$, ε has a value of 0.42. Let this value be ε_o. Then, using Equation 14,

$$k_s = \frac{(\Delta t) m^2 W_s}{DLZ} = \frac{(0.05)(1)^2(500)}{1 \times 1 \times 10} = 2.5$$

Enter Fig. 19 at $k_s = 2.5$ and move horizontally to an interpolated curve for $\varepsilon_o = 0.42$. Then, directly below on the ε_1 scale, read $\varepsilon_1 = 0.83$. Therefore, minimum film thickness will be

$$h_o = 0.5 \times 10^{-3}(1 - 0.83) = 0.000085$$

This is an acceptable value for minimum film under shock loading.

Some error is introduced when short bearings with a small L/D ratio are considered because the assumption was made in the derivation of k_s that lubricant does not flow in the axial direction. However, shock load factors in Fig. 19 can be used with reasonable accuracy for bronze bearings having L/D ratios as low as 0.5.

Lightly Loaded, High-Speed Bearings

An unstable condition sometimes experienced by lightly loaded, high-speed bronze sleeve bearings is known as "half-frequency whirl." This phenomenon is very serious and troublesome, especially with vertical guide bearings, and results from instability of the oil film. Half-frequency whirl occurs when the shaft starts to whirl around in the clearance space. If the condition becomes serious enough, shaft and bearing may destroy themselves. This type of whirl is defined as a condition in which the center of the journal rotates or orbits about the center of the bearing at a frequency equal to approximately one-half the rotational or spin speed of the shaft.

Where speed of the shaft is less than the first critical speed, half-frequency whirl will begin to occur at a shaft speed determined approximately by

$$N_c = k_c \times 10^{-3} \left[\frac{DNZ}{m^3 W_m} \right]^{1/2} \qquad (15)$$

Whirl-speed factor k_c is obtained from Fig. 20. Enter the chart at the bottom for the proper value of bearing characteristic number, proceed upward to the desired curve of L/D, and then move horizontally to read the value of k_c on the vertical scale.

If the computed value of N_c is greater than the contemplated operating speed, the journal will not suffer from half-frequency whirl. However, if N_c is less than the desired operating speed, the journal

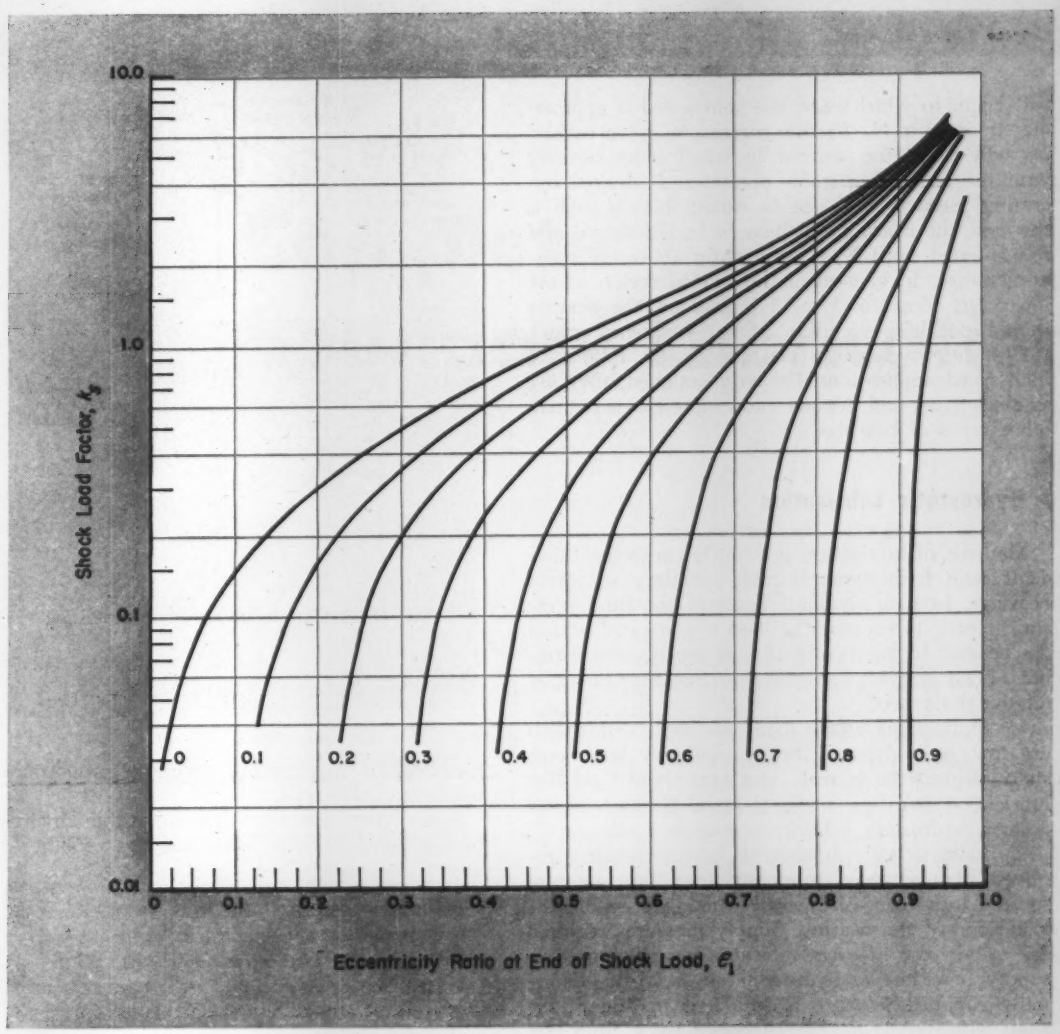


Fig. 19—Shock-load factors at various initial and final eccentricity ratios for 180 and 360-deg bronze bearings.

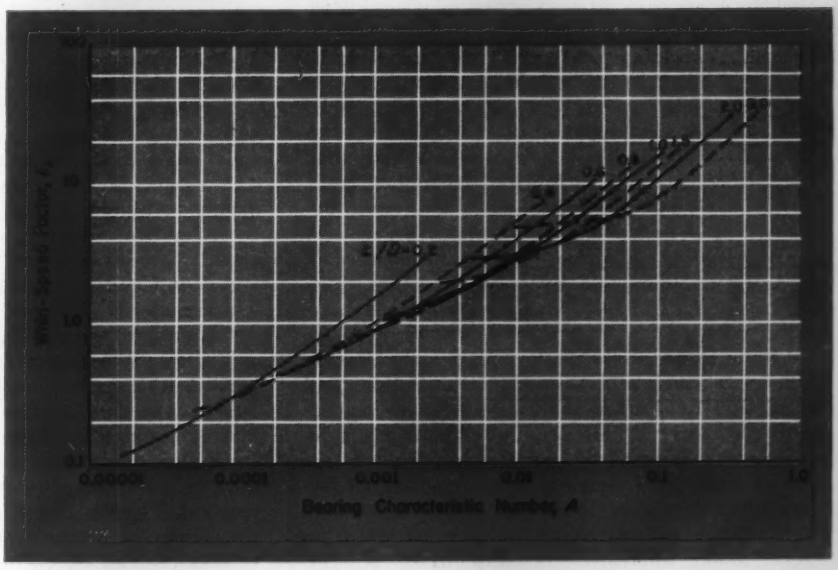


Fig. 20—Whirl-speed factors for 360-deg full-film lubricated bronze bearings having various L/D ratios.

will begin to whirl when the spin speed is approximately equal to N_c. Further increase in speed beyond N_c will cause the journal to whirl more severely with the result that stable operation at desired operating speed N will not be obtainable. If such is the case, the bearing will have to be redesigned and re-evaluated until N_c is sufficiently above the operating range. In general, if the shaded region in the lower left corner of Fig. 13 is avoided, the bearing should not be susceptible to half-frequency whirl.

Cast bronze bearings can readily be applied to high-speed applications. Properly designed, they are as efficient as, and in some cases more efficient than, other types of bearings.

Hydrostatic Lubrication

Methods of lubrication previously considered have dealt with hydrodynamic and boundary-lubricated bearings. In hydrodynamic bearings the fluid pressure needed to support the load is generated within the bearing by relative motion of the bearing members. Load-carrying capacity therefore depends upon relative shaft speed.

In applications where loads are high and speeds are low, hydrodynamic lubrication may be impossible. When this is true, and when full-fluid-film lubrication with no metal-to-metal contact is still desired, hydrostatic lubrication may be used.

A hydrostatically lubricated bronze bearing receives high-pressure lubricant from an external source. Lubricant is injected into a recess in the load zone of the bearing. Supply pressures required are usually far in excess of those normally used to supply lubricant to hydrodynamic bearings. Externally supplied pressure is sufficient to "float" the shaft with respect to the bearing. A thick, fluid film therefore separates shaft from bearing even at zero speed. In many cases where high starting loads exist, the load is hydrostatically supported until the unit is up to speed. External pressure is then removed and the load is supported hydrodynamically. At other times when speeds are low, hydrostatic pressure is applied continuously.

Usually, hydrodynamic bearings can depend on boundary and mixed-film lubrication for their starting periods, especially when loads are speed-dependent. If a bronze sleeve bearing is either very highly loaded at start-up or does not have sufficient speed to maintain full hydrodynamic film, high wear rates, high temperatures, and shortened bearing life may result.

Determination of the performance of hydrostatic bearings is a specialized aspect of lubrication. Full coverage of hydrostatic lubrication is presently beyond the scope of this Manual. However, many authors and investigators have done work in the field of hydrostatic bearings. Fuller[2] covers hydrostatic lubrication quite thoroughly. Loeb[4] determines characteristics of hydrostatic bearings by using an electric analog approach. Loeb and Rippel[5] describe

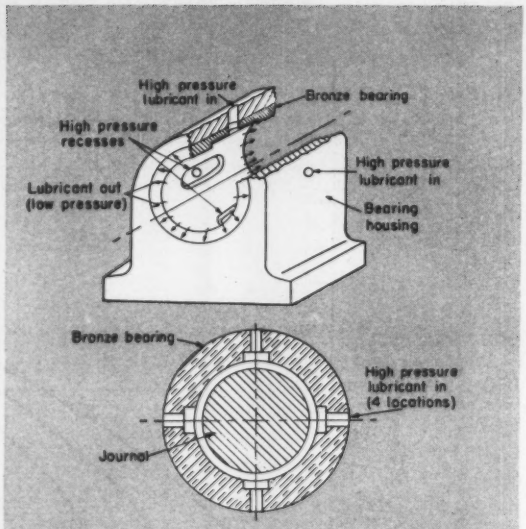


Fig. 21—Typical hydrostatic bronze bearing.

methods for determining optimum proportions for bearings of this type.

Some very distinct advantages that hydrostatic bronze bearings have over bearings of other types are:

1. High load-carrying capacity at low speed.
2. Extremely low running friction.
3. Zero starting friction (at zero speed).
4. High stiffness.
5. High reliability.
6. Predictable load-carrying capacity.
7. Almost infinite life.

Coefficients of friction much lower than the 0.001 of hydrodynamic and rolling-element bearings are possible with hydrostatic lubrication.

A typical hydrostatic bronze bearing with several high-pressure recesses is shown in Fig. 21. Lubricant under pressure is pumped into the bearing recesses and flows out across the fitted area of the bearing. All hydrostatic bearings may be analyzed by using two equations which relate load-carrying capacity, recess pressure, film thickness, viscosity, and flow. However, these equations contain constants which must be evaluated for each bearing size and configuration.

Hydrostatic bearings have been applied with a great deal of success in rolling mills, radio telescopes, optical telescopes, and other heavily loaded, slow-moving equipment. However, specialized techniques, which include thorough knowledge of hydraulic components accompanying the bearing package are required. The designer is cautioned against pursuing the design of bearings of this type without a full knowledge of all aspects of the problem.

Complete Boundary Lubrication

SINCE actual lubrication in boundary-lubricated sleeve bearings is practically nil, "boundary friction" might be a better name for this section. However, little as it may be, some lubrication is essential for the successful operation of a boundary-lubricated bearing. Before such a bearing can be designed, some understanding of the mechanism of boundary friction and lubrication must be gained.

Discussion which follows applies only to "boundary" friction, or the rubbing together of two surfaces without either a complete or a partial intervening oil film. This type of lubrication exists in one form or another in almost every kind of bearing. Even in well-designed and lubricated full-film bearings, some boundary friction must occur when starting and stopping.

Greases are very frequently used as boundary lubricants. Hence, the following discussion applies equally well to grease-lubricated sleeve bearings. Even though greases have a considerably higher viscosity than mineral oils, they do not allow a full film of lubricant to separate the journal from the bearing because the grease, too, is eventually forced from between the moving surfaces, and boundary friction will occur before reapplication of the grease.

Mechanism of Boundary Friction

Successful boundary lubrication of sleeve bearings requires the use of a suitable lubricant with proper journal and bearing materials. The correct combination will produce one or both of these effects: 1. A strong affinity for metal surfaces such that those molecules adjacent to the metal hold their position and greatly resist being displaced. 2. Formation of a soap film that is bound to the metal surfaces by the chemical reaction which occurs between lubricant and bearing and journal metals.

Fatty-Acid Lubricating Agents: Animal, vegetable, and marine fats and oils are superior to plain mineral oil as boundary lubricants. The ingredient common to all good boundary lubricants is some kind of fatty acid which occurs in chemical combination with glycerine or other high-molecular-weight alcohol. These fatty acids are often called "oiliness" agents. The three most important fatty acids used to enhance boundary-lubricating ability of lubricants are:

1. Stearic acid, as contained in lard oil and beef and mutton tallow.
2. Palmitic acid, a principal ingredient of cottonseed oil, palm oil, and animal and marine oils.
3. Oleic acid, which is found in high percentages in almost all animal and vegetable oils.

When a small amount of one of these fatty acids is added to mineral oils, boundary-lubrication friction values decrease very markedly. Hence, if the bearing is to operate under conditions of complete boundary lubrication using oil, a fatty-acid type additive should be specified for the oil. If a grease is to be used, no fatty acid need be specified be-

D = Journal diameter, in.
f_B = Coefficient of friction for complete boundary lubrication
L = Bearing length, in.
L_{max} = Maximum bearing length for complete boundary lubrication, in.
N = Rotational speed of journal, rpm
P_B = Frictional horsepower generated within complete boundary lubricated bearing, hp
T_2 = Lubricant film temperature for full-film lubrication, or bearing bore temperature for mixed-film and boundary lubrication, F
T_4 = Ambient atmosphere temperature, F
W = Steady load to be supported, lb

cause greases normally contain fatty acids in their composition.

The action of a fatty acid in reducing friction under boundary conditions is generally attributed to molecular adherence. The fatty acid adheres to the metal surface with sufficient strength to resist being torn off when the rubbing surfaces slide over each other. A simplified explanation is that the fatty-acid molecules orient themselves on the metal surface such that they all stand up like the pile of a carpet, Fig. 22. The molecular layers actually isolate the two metal surfaces and friction, which would be high in the absence of lubricant, is substantially reduced.

Present research indicates that a chemical reaction occurs between the fatty acid and the metal involved. Product of this reaction is a soap film that is chemically bound to the metal surface. Thus, a fatty acid is most effective as a friction reducer when the nature of the metal permits a chemical reaction. Bronze is classed as a reactive material and readily combines with fatty acids to produce low-shear-strength metallic soaps.

When a fatty acid is used with a reactive metal, breakdown of the extremely thin lubricating film does not occur at the melting temperature of the fatty acid but at a considerably higher temperature. Actual breakdown temperature depends on the nature of the metal and on the load and speed of sliding. It corresponds approximately to the stage at which the metallic soap film softens or melts. When breakdown temperature is reached, the fatty acid loses its boundary-lubricating properties, and the coefficient of friction increases, as indicated by the "fatty acid" curve in Fig. 23. Breakdown temperature, of course, depends upon the particular metallic soap formed by the reaction of fatty acid and bearing metal.

Rapid transition to the no-lubricating-film condition at breakdown is not desirable, since a temperature variation of only a few degrees could seriously affect performance of the bearing. Hence, when a boundary-lubricated sleeve bearing is expected to operate at elevated temperature or at high speed with high load, probable breakdown temperature of the metallic soap must be considered. The best source for this sort of information, once the particular lubricant and bronze bearing material are known, is the lubricant manufacturer. After returning to operating temperatures below the transition temperature, the fatty acid regains its boundary lubricating qualities.

Extreme-Pressure Lubricants: As has been stated, when bearing loads, speeds, and ambient temperature conditions combine to give surface temperatures ranging from 250 to 300 F, fatty acids and their products undergo thermal decomposition with a resulting increase in friction and surface damage. Therefore, under such conditions, some new kind of low-shear-strength film that is more stable must be formed.

The need for a suitable lubricant for high-speed hypoid gears led to the development of a class of lubricants containing extreme-pressure additives. These additives are called extreme-pressure lubricants, or just EP lubricants. Active chemicals that have proved to be effective in forming an organic film of low shear strength on the metal bearing surfaces are chlorine (chlorinated esters, etc.), sulfur (sulfurized lard oil, etc.), and phosphorus (tricresyl phosphate, etc.). In general, compounds containing these elements are used as additives to form, through reaction with metal surfaces, chlorides, sulfides, and phosphides. Such surfaces have relatively low shear strength so that rubbing between contacting surfaces occurs in the low-shear-strength surface film and thus protects the base metal. The surface films also have a relatively high melting point (iron sulfide, 2150 F; iron chloride, 1200 F) and will remain on the rubbing surfaces even at high contact temperatures.

However, if surface temperatures are below a 200 to 350 F range, the reaction of extreme-pressure additives with metal surfaces does not take place very rapidly. Consequently, as indicated in Fig. 23, until some temperature favorable to promoting the reaction is attained, these substances may prove relatively ineffective as boundary lubricants. For this reason, a small quantity of fatty acid is often included in the lubricant to provide effective lubrication at temperatures below the reaction temperature of the chemical additive. Friction characteristics of

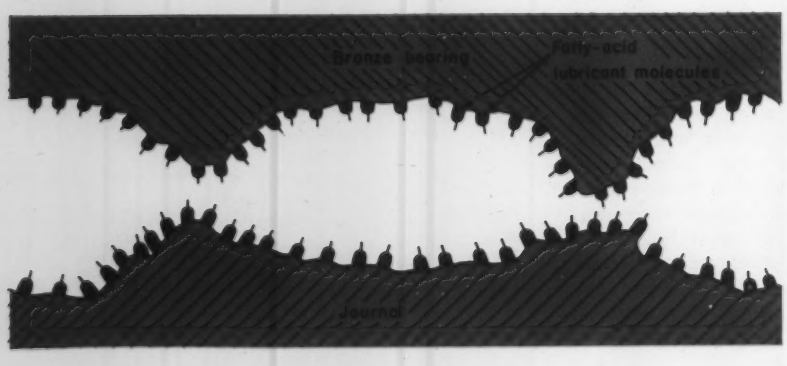


Fig. 22 — Fatty-acid lubricant molecules adhering to bearing and journal surfaces.

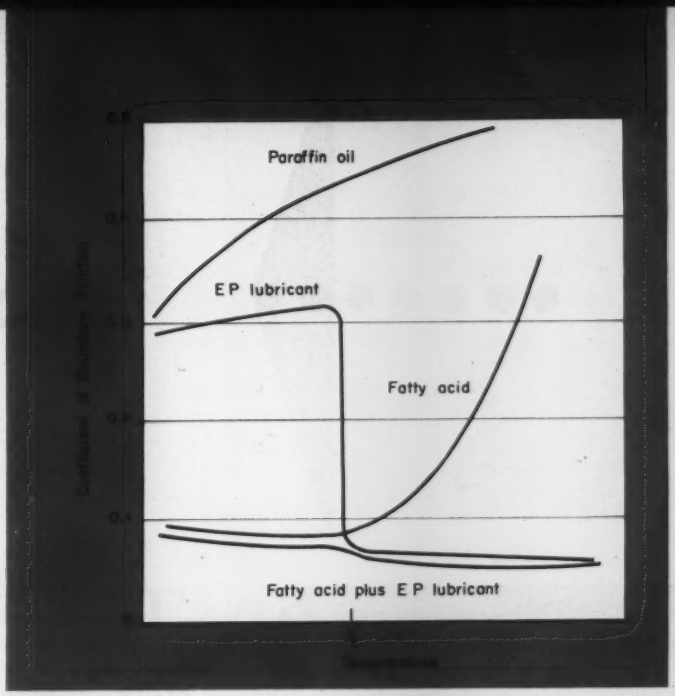


Fig. 23—Variation of coefficients of friction with temperature for several lubricants under complete boundary-lubrication conditions. (After Bowden.)

this "ideal" lubricant and characteristics for normal paraffin oil are also shown in Fig. 23.

The curve in Fig. 23 for a fatty acid is typical. The acid reacts with the metal surface to form a metallic soap. At the melting point of the soap, friction increases. The EP additive in a lubricant reacts slowly below some critical temperature, T_c, so that up to this temperature, lubrication is poor. Above this temperature, a protective, low-shear-strength, high-melting-temperature film is formed, and effective boundary lubrication is provided up to a very high temperature. The lowest curve is an idealized result when some fatty acid is added to an EP lubricant. Good boundary lubrication is provided by the fatty acid below T_c. Above T_c, the effectiveness of boundary lubrication is attributed chiefly to the EP additive.

Care should be exercised in the type of extreme-pressure compound selected. If reaction rate between lubricant additive and metal surface is too rapid, more harm than good may result. Continuous fast-reaction rates will lead to chemical corrosion. Hence, the EP additive selected should give rise to chemical reaction only at temperatures or pressures where welding and tearing of bearing surfaces becomes so imminent that high wear and subsequent seizure are likely to result.

As a brief review, major facts of boundary friction and lubrication are:

1. Unmodified mineral oils are not good boundary lubricants.

2. Fatty acids are added to a lubricant to improve its boundary lubricating properties by: 1. Adhering very strongly to the surfaces, thereby forming very thin films which reduce friction and prevent metal-to-metal contact. 2. Combining chemically with the bearing materials to form low-shear-strength metallic soaps whose maximum operating temperature is governed by breakdown temperature of the metallic salt.

3. Extreme-pressure additives are used to increase permissible surface temperatures for satisfactory boundary lubrication. Reaction rate should be controlled to prevent undue chemical corrosion.

Designing for Complete Boundary Lubrication

Since design of complete boundary lubricated bronze bearings follows the same lines as the design of mixed-film lubricated bronze bearings, complete discussion of the procedure will be presented in the next section, *Mixed-Film Lubrication*.

Required length for complete boundary lubricated sleeve bearings is determined from*

$$L_{max} = \frac{f_B N W}{15.28(T_2 - T_4)} \qquad (16)$$

This equation yields satisfactory results where continuous bearing operation under conditions of complete boundary lubrication at given temperature, load, and speed is required. If operation is intermittent with regard to load and speed, shorter bearing lengths than indicated by Equation 16 may be used. Also, since diameter of the bearing does not enter into Equation 16, some limit on allowable L/D ratio should be set. In general, L/D ratios larger than 4 to 1 should be avoided.

Horsepower required to overcome friction in a complete boundary-lubricated sleeve bearing is obtained with*

$$P_B = 7.87 f_B D N W \times 10^{-6} \qquad (17)$$

Clearance ratios for boundary-lubricated bronze bearings are similar to those used for full-film lubricated bronze bearings.

*Derivation and correct application of Equations 16 and 17 are explained in the next section, *Mixed-Film Lubrication*.

Mixed-Film

A = Bearing characteristic number
A_1, A_2 = Areas of heat dissipation
C = Radial clearance, in.
D = Journal diameter, in.
F = Bearing friction force, lb
f' = Minimum coefficient of friction for mixed-film lubrication
f_B = Coefficient of friction for complete boundary lubrication
f_F = Coefficient of friction for full-film lubrication
f_M = Coefficient of friction for mixed-film lubrication
K', K'' = Coefficients of heat transfer
k_L = Bearing length factor for mixed-film lubrication
k'_L = Minimum bearing length factor for mixed-film lubrication
k_8, k_7 = Simplifying factors
k_8, k_9, k_{10} = Factors used in Table 3
L = Bearing length, in.
L_{max} = Maximum bearing length for complete boundary lubrication, in.
L_{min} = Minimum bearing length for fluid-film lubrication, in.
m = Clearance factor
$= 1000(2C)/D$
N = Rotational speed of journal, rpm
P_M = Frictional horsepower generated within mixed-film lubricated bearing, hp
p = Projected area unit load, psi
Q = Side-leakage oil flow, or oil-flow feed rate, gpm or drops per min
Q' = Minimum oil flow required for full-film lubrication, gpm or drops per min
Q'_{min} = Minimum oil flow required for full-film lubrication when bearing length is L_{min}, gpm or drops per min
T_2 = Lubricant film temperature for full-film lubrication, or bearing bore temperature for mixed-film and boundary lubrication, F
T_3 = Surface temperature of bearing housing, F
T_4 = Ambient atmosphere temperature, F
V = Shaft surface velocity, fpm
W = Steady load to be supported, lb
W_B = Load supported by lubricant film under complete boundary lubricating conditions, lb
W_F = Load supported by lubricant film under full-film lubricating conditions, lb

THOUSANDS of bronze sleeve bearings operate under mixed-film conditions, either by intent or by chance. Lubrication by frequent hand oiling, mechanical feed, wick feed, waste pack, or drop feed usually results in mixed-film operation. Bearings operate under mixed-film conditions because: 1. Load is too large. 2. Speed is too low. 3. Viscosity is too low. 4. Lubricant is restrained.

The first three reasons result in a large value for bearing characteristic number, A. For the fourth reason, rate of lubricant application is below minimum requirements, or $Q < Q'$.

Mechanism of Mixed Friction

In a bronze sleeve bearing operating under conditions of mixed-film lubrication, part of the total load carried by the bearing is supported on a boundary film in the areas of closest approach between journal and bearing. The remaining portion of the load is supported by hydrodynamic pressure developed in the oil-filled, depressed regions of apparent contact area. Hence, total friction encountered when operating under conditions of mixed-film lubrication depends upon the coefficient of friction for boundary friction, f_B, and the coefficient of friction for fluid friction, f_F.

As previously mentioned in the discussion of Fig. 3, the value of f_B ranges from 0.08 to 0.14 depending upon the combination of lubricant and bearing materials. For the case of fluid friction, a safe assumption is that coefficient f_F will be on the order of 0.002. Minimum coefficient of mixed friction, f', is approximately equal to 0.020, while the maximum coefficient of mixed friction approaches the coefficient of boundary friction. When all the load is supported on a boundary film because of either lack of lubricant or slow speed, both of which prevent build-up of hydrodynamic pressure to support a portion of the load, boundary friction constitutes the total friction encountered.

Based on the assumption that load is shared between a boundary film and many partial fluid films,

$$W = W_B + W_F$$

Lubrication

Total friction force will then be total load times coefficient of mixed friction and is the sum of boundary friction and fluid friction forces, or,

$$f_M W = f_B W_B + f_F W_F$$

By combining the two previous equations, the solution for coefficient of mixed-film lubrication becomes

$$f_M = f_F + (f_B - f_F)\frac{W_B}{W} \qquad (18)$$

If all the load is carried on a boundary film, then $W = W_B$, $W_B/W = 1$, and $f_M = f_B$. Conversely, if all the load is carried on a fluid film and there is no boundary friction, $W_B = 0$ and $f_M = f_F$. Between these two end conditions, ratio W_B/W must be determined to evaluate f_M.

As discussed in *Full-Film Lubrication*, a minimum flow rate of lubricant, Q', must be supplied to a given sleeve bearing subjected to a given load and speed to permit it to operate hydrodynamically. If less than this minimum flow rate is supplied, some boundary friction will occur and an immediate increase in bearing friction will signify the onset of mixed-film conditions. As oil-feed rate is further reduced, the logical assumption is that ratio W_B/W will increase since less lubricant is available. Hence, an approximate relationship between W_B/W and oil-feed rate Q can be established. A suitable equation for this relationship is

$$\frac{W_B}{W} = 1 - \frac{(f_B - f')}{(f_B - f_F)}\left(\frac{Q}{Q'}\right)^2 \qquad (19)$$

If oil-feed rate is known, the coefficient of mixed friction can be obtained by substituting Equation 19 into Equation 18, or,

$$f_M = f_B - (f_B - f')\left(\frac{Q}{Q'}\right)^2 \qquad (20)$$

Coefficient of boundary friction, f_B, for steel journals running on cast bronze ranges from 0.08 to 0.14, depending upon the lubricant. An observed approximate value for f' is 0.020, which becomes the approximate coefficient of mixed friction when oil-feed rate Q equals minimum oil flow Q'. Equation 10*a* or 10*b* is used to evaluate Q'.

One important variable not included in the preceding discussion is the effect of wearing-in of bearing members. If a sleeve bearing is given an opportunity to wear-in, the necessary value of Q' will probably decrease. Hence, the preceding analysis is on the safe side in that predicted coefficients of friction may be somewhat higher than actual values. Because this reduction in Q' cannot be evaluated, no attempt is made to include it in the equations.

Coefficient of mixed friction is plotted against oil-feed ratio Q/Q' for various values of coefficient of boundary friction in Fig. 24. Notice that the mini-

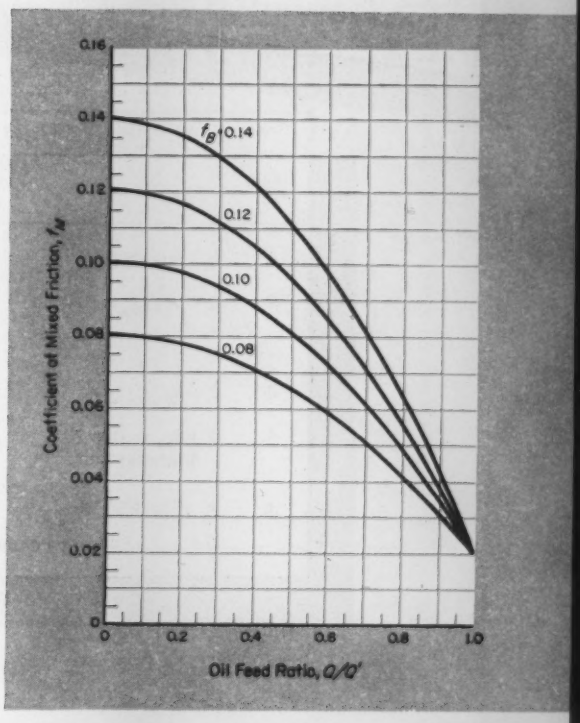


Fig. 24—Coefficients of mixed friction for bronze bearings operating with mixed-film lubrication.

Table 3 — Design Sheet for Mixed-

Part A -- Known Data

	Symbol	Value	Units
Total steady load	W	____	lb
Journal speed	N	____	rpm
Journal diameter	D	____	in.
Clearance factor	m	____	—
Bearing bore temperature	T_2	____	F
Ambient atmosphere temperature	T_4	____	F
Coefficient of boundary friction (estimated)	f_B	____	—

Part B -- Simplified Factors

	Calculation	Value
k_8	$NW/(T_2 - T_4)$	____
k_9	$0.0043\,W/D$	____
k_{10}	$(3.32 \times 10^{-3})\,mD^2N$	____

Part C -- Final Calculation Form

Step No.		Original Values	Values for First Adjustment	Values for Second Adjustment
1.	k_L (step 5)	$k_L = 0.00131$	____	____
2.	$L = k_L\,k_8$, in.	$L'_{min} = 0.00131\,k_8$ = ____	____	____
3.	$L + k_9$	____	____	____
4.	$Q' = k_{10}$ x step 3, drops per min	Q'_{min} = ____	____	____
5.	k_L (Fig. 25) for Q = ____ drops per min	____	____	____

Film Lubricated Bronze Bearings

Preliminary Steps

Part A: Fill in values dictated by the problem.

Select m from Fig. 6 through 10 for the specified class of machinery and operating speed.

Choose a suitable value for T_2. Temperature T_2 should not be so high as to weaken the bearing material or damage the lubricant. For cast leaded bronze, T_2 should never exceed 450 F if the lubricant can function properly at that temperature.

Estimate a value for f_B.

Part B: Make calculations indicated, obtaining necessary values from Part *A*, and record the answers.

Final Calculations

Step 1. Use $k_L = 0.00131$ in first column as indicated. Taken from Equation 23, $k_L = f_M/15.28$. When $Q = Q'$, $k_L = k'_L = 0.00131$ regardless of the value of f_B. Factor k_L is plotted in Fig. 25. In second and subsequent columns, copy k_L from Step 5 of preceding column.

Step 2. Calculate L'_{min} in first column as indicated. In subsequent columns, calculate L.

Step 3. Add the result of Step 2 and factor k_9 from Part *B*.

Step 4. Multiply the result of Step 3 by factor k_{10} from Part *B*. Entry in first column equals Q'_{min}, which, for the given conditions, will tend to reduce boundary friction to a minimum for a bearing of length L'_{min}. If Q'_{min} is acceptable and can be continuously supplied to the bearing, and if L'_{min} is also acceptable, the design is completed. However, if bearing length is too long and will not fit the application, either full-film, hydrodynamic lubrication must be used, if possible, or bearing diameter must be varied. If oil-flow rate appears excessive, and if the L/D ratio is small and space is available for increased bearing length, compute a new value for k_L in Step 5.

Step 5. Determine a new value of k_L from Fig. 25 if permitted by conditions listed in Step 4. First select an acceptable value for Q and record it. This oil-flow rate is used to determine all subsequent new values of k_L. Then, entering Fig. 25 at the right-hand side for the selected value of Q, move horizontally left to the value of Q' obtained in Step. 4. From this point, move vertically to the value of f_B estimated in Part *A*. Finally, move horizontally from the f_B value to the left-hand scale to obtain the new value of k_L. Interpolate for curves Q' and f_B when necessary. Record the value of k_L.

Numerical Example

Determine the length of a cast-bronze sleeve bearing for a precision spindle of hardened, ground steel. Design for mixed-film lubrication.

Known values for the Design Sheet, Part *A*, are: $W = 1000$ lb; $N = 200$ rpm; $D = 1$ in.; $m = 1.1$ from Fig. 6; $T_2 = 250$ F; $T_4 = 100$ F; $f_B = 0.10$ estimated.

Calculations for Part *B* are: $k_8 = 200\ (1000)/(250 - 100) = 1333$; $k_9 = 0.0043\ (1000)/1 = 4.3$; $k_{10} = 3.32 \times 10^{-3}\ (1.1)(1)^2(200) = 0.726$.

Values for the complete design are tabulated for Part *C*.

Explanation: First entry for Step 1 in the table for Part *C* is given for k'_L. First entry for Step 2 is $0.00131(1333) = 1.756$. First entry for Step 3 is the sum of 1.756 and 4.3. First entry for Step 4 is $0.726\ (6.056) = 4.4$.

Thus, if at least 4.4 drops of oil per minute are supplied to a bearing approximately 1¾ in. long, satisfactory mixed-film operation should result. A flow rate less than 4.4 drops per min will result in more boundary friction and, hence, will require a greater bearing length.

For a complete illustration of the design procedure, suppose the flow rate can be no more than 3 drops per min. A new value of k_L is obtained from Fig. 25: Enter the graph at $Q = 3$ and move horizontally to the location corresponding to 4.4 for Q' in Step 4. Move vertically to the curve for $f_B = 0.10$. Then move horizontally to the left-hand side of the graph and read $k_L = 0.0040$. This value is entered for Step 5 and also as the second entry for Step 1.

The process is then repeated using the new value of k_L. The new value for L is $0.0040\ (1333) = 5.332$. For Step 3, $5.332 + 4.3 = 9.632$, and for Step 4, $Q' = 0.726\ (9.632) = 7.0$ drops per min.

Since the calculation process continues until no change occurs in two successive values of L, or, in effect, for k_L, a new value for k_L is again taken from Fig. 25: Enter the graph at the desired value of $Q = 3$, move horizontally to $Q' = 7.0$, move vertically to $f_B = 0.10$, and move horizontally to $k_L = 0.0055$.

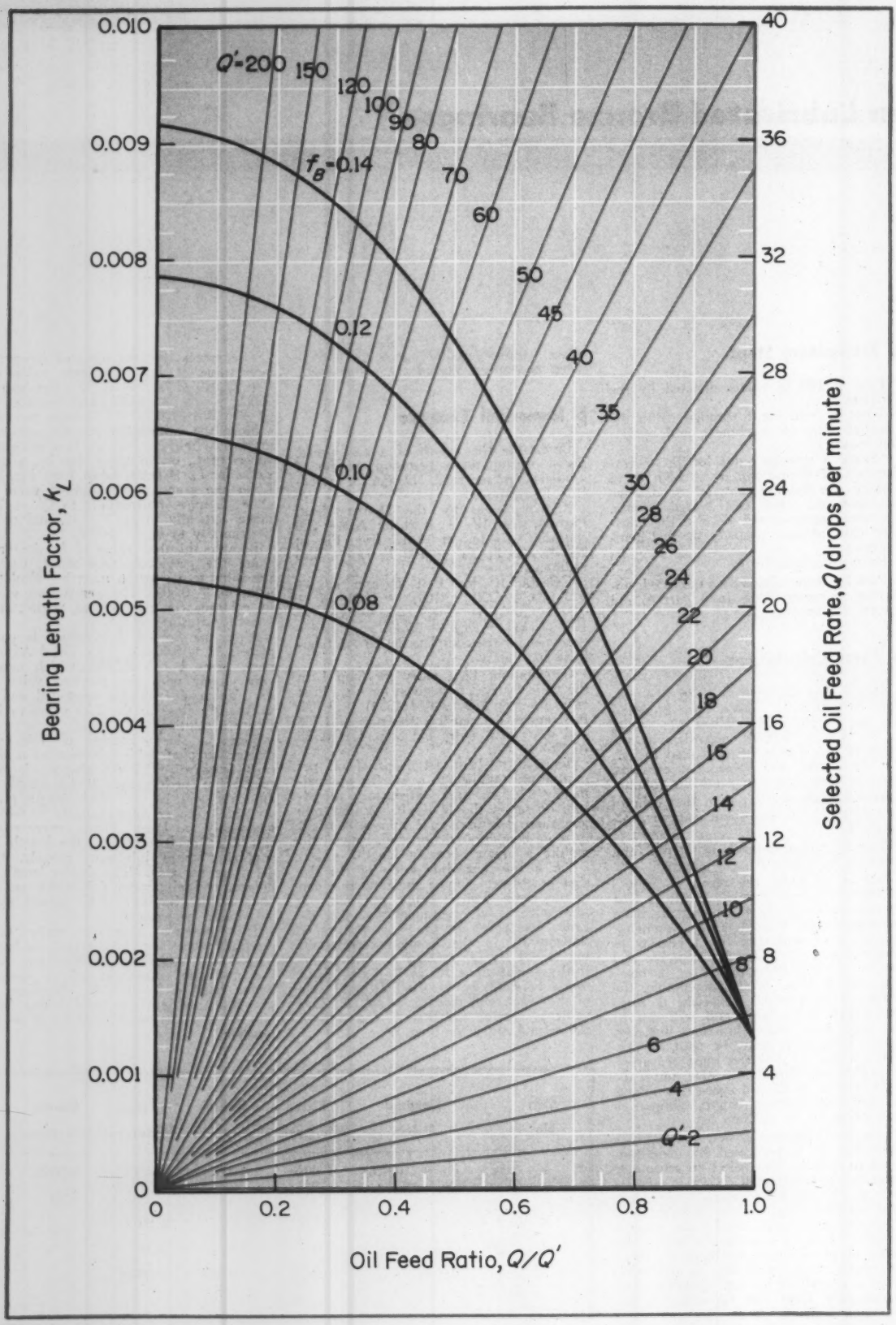
Because this last value of k_L does not equal the previously used value, 0.0040, the third set of entries must be calculated using $k_L = 0.0055$. Thus, entries are made in columns for the Second, Third, and Fourth Adjustment.

After the Second Adjustment is completed, k_L is 0.00585. The Third Adjustment gives $k_L = 0.0059$, which agrees very closely with the previous value of k_L. Value of L is also computed and is sufficiently close to the 7.79 value to indicate a solution.

Thus, a sleeve bearing of 1-in. diameter, supplied with lubricant at a rate of 3 drops per min, will give satisfactory mixed-film performance if its length is approximately 7.8 in. This length gives an L/D ratio of approximately 8, which is entirely too large. Hence, every effort should be made to reduce the length by supplying more lubricant, namely, the 4.4 drops per min. The shorter length is necessary if alignment difficulties are to be avoided. Ratios of L/D greater than 4.0 should be avoided.

This example illustrates, quite dramatically, the effect of "starving" the bearing—that is, supplying less lubricant than the minimum rate required to operate under full-film conditions. Needless to say, it is highly recommended that flow rate be at least equal to Q'_{min} if at all possible.

Step No.		Original Values	First Adjustment	Second Adjustment	Third Adjustment	Fourth Adjustment
1.	k_L	$k'_L = 0.00131$	0.0040	0.0055	0.00585	0.0059
2.	L	$L'_{min} = 1.756$	5.332	7.34	7.79	7.80
3.	$L + k_9$	6.056	9.632	11.64	12.09	
4.	Q'	$Q'_{min} = 4.4$	7.0	8.16	8.76	
5.	k_L $Q = 3$	0.0040	0.0055	0.00585	0.0059	


Bearing Length Factor, k_L
Selected Oil Feed Rate, Q (drops per minute)
Oil Feed Ratio, Q/Q'
Q'-200
150
120
100
90
80
70
60
50
45
40
35
30
28
26
24
22
20
18
16
14
12
10
8
6
4
Q'-2
f_B-0.14
0.12
0.10
0.08
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
0.2
0.4
0.6
0.8
1.0
40
36
32
28
24
20
16
12
8
4
0

mum value of f_M for each value of f_B equals 0.020 when $Q/Q' = 1$. At the extreme left-hand side of the graph, when $Q/Q' = 0$, f_M equals f_B in each case and indicates complete boundary-friction conditions. Between the two limits, f_M is dictated by the oil-feed ratio and f_B.

Designing for Mixed-Film Lubrication

Regardless of whether a bronze bearing is operating on a full, mixed, or boundary film of lubricant, frictional energy is generated within the bearing. Frictional heat must be removed from the bearing at a rate equal to the rate of heat generation if some steady-state operating temperature is to be obtained. Since only small flow rates are associated with boundary and mixed-film lubricated bearings, practically all heat generated within the bearing must be conducted through the bearing walls and eventually dissipated to ambient atmosphere.

Frictional energy to be dissipated is the product of force required to overcome friction in the bearing and journal surface speed or FV. If steady-state temperature conditions are to be attained,

$$FV = K'A_1(T_2 - T_3) = K''A_2(T_3 - T_4)$$

where K' and K'' are heat-transfer coefficients and A_1 and A_2 are heat-dissipating areas.

Since $F = f_M W$ and A_1 and A_2 are proportional to the product of bearing length and diameter ($A_1 = k_6DL$, $A_2 = k_7DL$), by substituting for F, A_1, and A_2,

$$f_M WV = K'k_6DL(T_2 - T_3) = K''k_7DL(T_3 - T_4)$$

$$f_M V\left(\frac{W}{DL}\right) = k_6K'(T_2 - T_3) = k_7K''(T_3 - T_4)$$

When the last equation is combined with information available on temperature rises for mixed-film conditions,

$$pV = \frac{k_7(T_2 - T_4)}{f_M} \tag{21}$$

Value of k_7 depends upon heat-dissipating qualities of the bearing, but to obtain a value for k_7, more empirical data are required. An observed fact is that maximum permissible value of pV for mixed-film lubrication is approximately 50,000 lb-ft per in.^{2} per min. For pV to be maximum in Equation 21, temperature difference $T_2 - T_4$ must be maximum, and the coefficient of mixed friction must be minimum. Factor k_7 remains constant, since it is only a constant of proportionality. For continuous operation on cast bronze, an acceptable upper limit for T_2 would be approximately 325 F. If T_4 is chosen as 75 F, then $(T_2 - T_4)_{max}$ equals 250 F. Also, from previous discussion and Fig. 24, minimum value of f_M is 0.020. By substituting these various values into Equation 21, k_7 is found to equal 4. Thus,

$$pV = \frac{4(T_2 - T_4)}{f_M} \tag{22}$$

Bearing Length: To make Equation 22 more useful for design purposes, p can be replaced with W/DL and V with $\pi DN/12$. By rearranging,

$$L = \frac{f_M NW}{15.28(T_2 - T_4)} \tag{23}$$

The only unknown quantity is L, since W, N, and T_4 are usually known for the problem. If a bearing-bore temperature compatible with lubricant and bearing materials is assigned to T_2, and a value of f_M is computed from Equation 20, a bearing length can be determined that will satisfy the design requirements. However, evaluation of f_M may require more manipulation than has been indicated.

With $f' = 0.020$, the coefficient of mixed friction for use in Equation 23 is obtained from Equation 20:

$$f_M = f_B - (f_B - 0.020)\left(\frac{Q}{Q'}\right)^2 \tag{20a}$$

In Equation 20a, minimum flow for full-film lubrication Q' is obtained from Equation 10b (repeated here for convenience):

$$Q' = 3.32 \times 10^{-3}\left(L + 0.0043\frac{W}{D}\right) mD^2N \tag{10b}$$

To evaluate Equation 10b requires a value for L, but L at this stage is unknown. However, from Equation 20a and Fig. 24, when $Q/Q' = 1$, f_M equals 0.020, and when $Q/Q' = 0$, f_M equals f_B. If these values are substituted into Equation 23 for the given speed, load, and temperature limits, maximum bearing length when $Q = 0$, and minimum bearing length when $Q = Q'$ can be determined.

Thus, for complete boundary lubrication,

$$L_{max} = \frac{f_B NW}{15.28(T_2 - T_4)} \tag{16}$$

and for the other condition, that of minimum length for fluid-film lubrication,

$$L_{min} = \frac{T_2 - T_4}{0.00131NW} \tag{24}$$

The necessary oil-feed rate that will allow use of L_{min} is obtained from Equation 10b by substituting for L the value of L_{min} as computed from Equation 24, or,

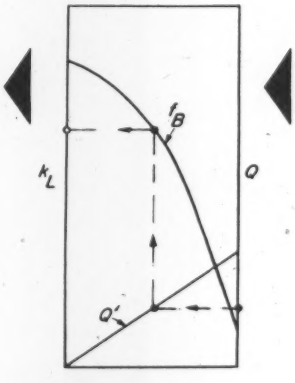


Fig. 25—Bearing-length factors for bronze sleeve bearings operating with mixed-film lubrication.

$$Q'_{min} = 3.32 \times 10^{-3} \left(L_{min} + 0.0043 \frac{W}{D} \right) mD^2N \quad (25)$$

If quantity Q'_{min} appears impractical or impossible to supply because of the high rate, an acceptable flow-rate value is assigned to Q. With this assigned flow rate, a repetitive process determines a length L that will give satisfactory service.

For initial calculations at minimum conditions, $Q/Q' = Q/Q'_{min} = 1$. Now, with Q selected and being smaller than Q'_{min}, ratio Q/Q' also becomes smaller, or less than 1. Consequently, as shown by Equation 20*a* and Fig. 24, f_M becomes larger than 0.020. Then, with f_M larger in Equation 23, L will be longer than L_{min}. For this longer value of L, Equation 10*b* shows that a new value for Q', greater than the value obtained for Q'_{min}, is required.

With the assigned oil-feed rate still desired, the new ratio for Q/Q' becomes slightly smaller than the previous ratio because the new Q' is larger than the previous Q', which, since this is the first cycle, is actually Q'_{min}. Thus, the second cycle starts with new values being determined for f_M and L. After several cycles, a solution is obtained when no further change occurs in length L.

Simplified Design Method

Outlined in Table 3 is a systematic procedure for designing bronze bearings under mixed-film conditions. All necessary entries and computations can be made in the spaces provided. Part *A* of Table 3 lists all data needed to compute the required bearing length. This information is known from conditions and requirements at the start of the design. Part *B* requires computation of factors that simplify final calculations. All information necessary to obtain these factors is taken from Part *A*. Part *C* indicates final calculations for determining bearing length L. In most cases several trials will be required before a satisfactory length is obtained, and space is indicated for initial cycles. Certain values required to complete the calculations can be easily determined from Fig. 25.

A sample problem is included that illustrates full use of the design method. Table 3 outline is used, and explanations are given throughout the procedure.

Power Requirements

With required bearing length L and oil-feed ratio Q/Q' determined, expected coefficient of mixed friction can be obtained from either Equation 20*a* or Fig. 24. Then, power required to overcome mixed-film friction in the bearing is

$$P_M = 7.87 \times 10^{-6} f_M DNW \quad (26)$$

References

Material contained in this Design Manual has been taken from many different sources. Almost all of it has been reworked to suit the particular needs of the Manual. Hence, the author is deeply indebted to the works of many experimenters and writers in the field of sleeve bearing design, analysis, and application. In particular, published material most heavily drawn from is:

1. B. Sternlicht and D. D. Fuller—"Investigation of Minimum Oil Feed Rates for Fluid-Film Conditions in Journal Bearings," *ASME Transactions*, Vol. 78, 1958, p.1193.
2. D. D. Fuller—*Theory and Practice of Lubrication for Engineers*, John Wiley & Sons Inc., New York, 1956.
3. A. A. Raimondi and J. Boyd—"A Solution for the Finite Journal Bearing and Its Application to Analysis and Design—III," *ASLE Transactions*, Vol. 1, No. 1, April, 1958.
4. A. M. Loeb—"The Determination of the Characteristics of Hydrostatic Bearings Through the Use of the Electric Analog Field Plotter," *ALSE Transactions*, Vol. 1, No. 1, April, 1958.
5. A. M. Loeb and H. C. Rippel—"Determination of Optimum Proportions for Hydrostatic Bearings," *ASLE Transactions*, Vol. 1, No. 2, Oct., 1958.
6. D. D. Fuller—*A Survey of Journal Bearing Literature*, ASLE publication, 1958.

Future Articles

At this point, all the information needed for determining dimensions, lubricant requirements, operating temperatures, and power requirements of bronze sleeve bearings has been presented. However, supplementary information is necessary for complete design of the bearing. Articles covering viscosity and lubricants, bearing materials, grooving, and lubricant application will follow in future issues of MACHINE DESIGN.

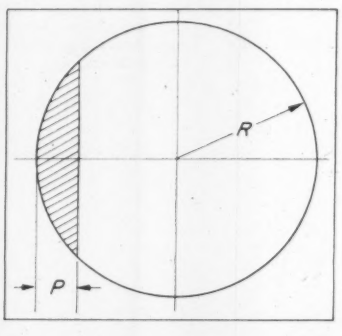
Tips and Techniques

Segment Areas Graphically

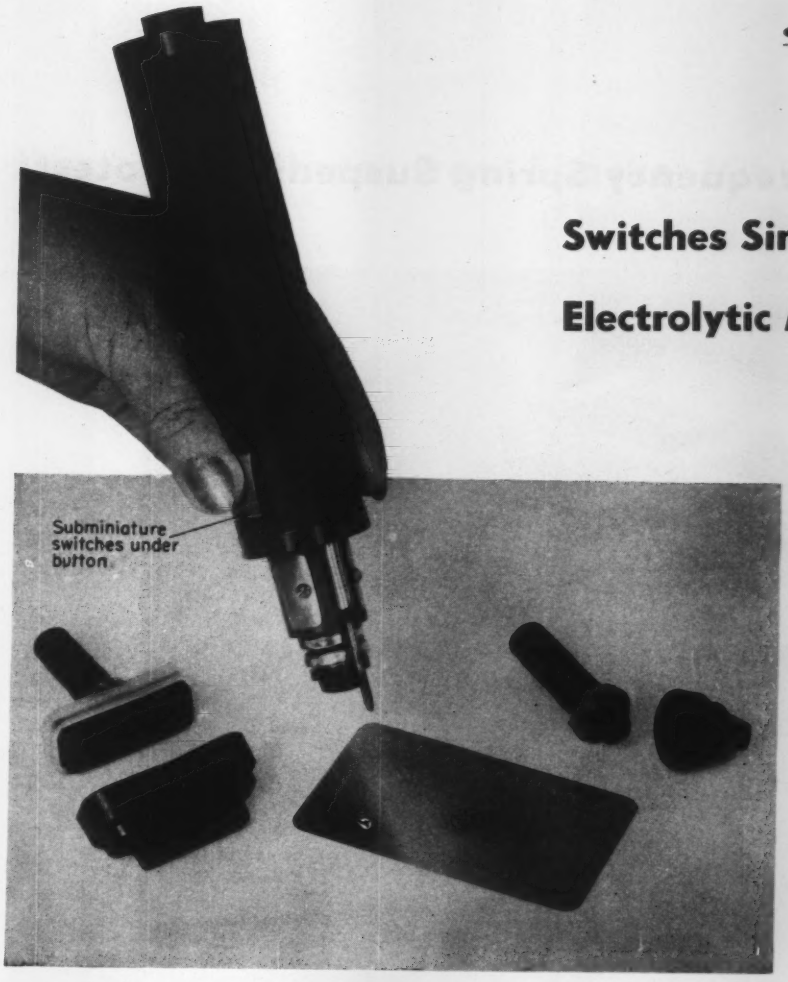
A practical formula for the area of a circular segment is:

$$A = R^2 \left[\cos^{-1} \left(1 - \frac{P}{R} \right) - \left(1 - \frac{P}{R} \right) \sqrt{1 - \left(1 - \frac{P}{R} \right)^2} \right]$$

where the symbols are as shown. This form is used by engine designers in calculating the area of a circular port uncovered by a piston.—G. GARRINGTON, *Convair Corp., San Diego, Calif.*



Switches Simulate AC in Electrolytic Marker



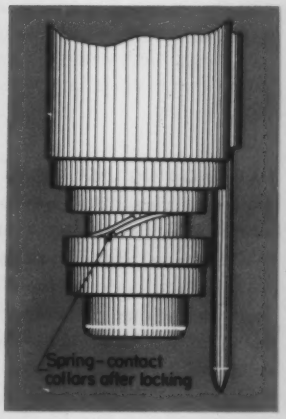
BLACK OR WHITE MARKS can be made on all commercial metals and alloys, including carbide and titanium, with a new electrolytic marker. White marks are produced by placing stencil on part for 1 to 4 sec, completing an anodic etch.

To make a black mark, the stencil is positioned against the part for 1 to 4 seconds, as before, then the polarity switch is pressed. This action causes a redeposit of metallic oxides in the mark which produces the black appearance. The part, in effect, becomes cathodic and the oxides are plated back in.

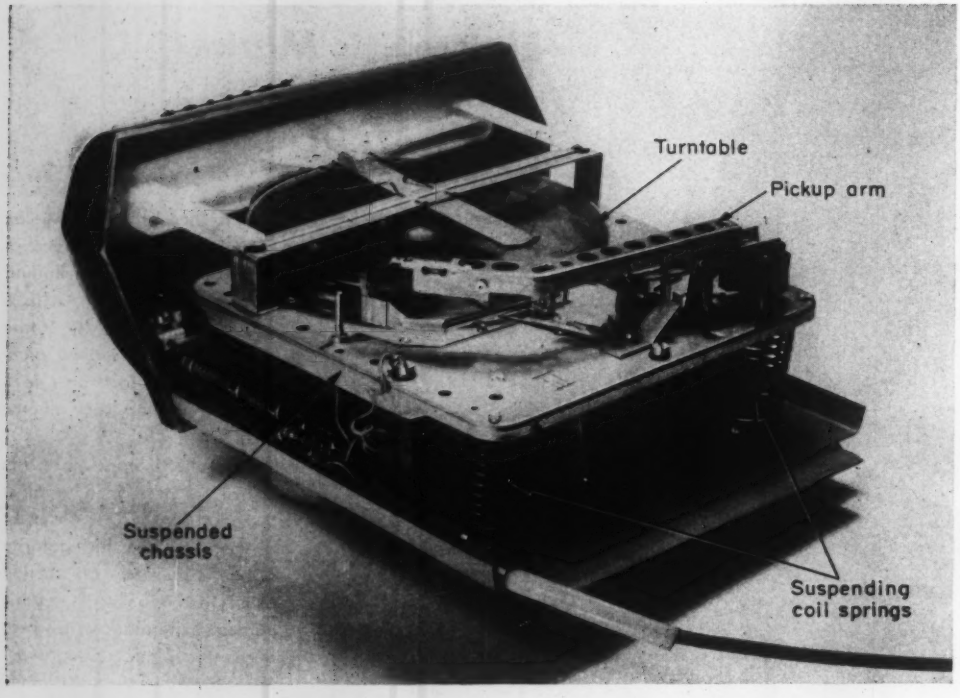
A pair of subminiature switches reverse polarity of the circuit when closed. The polarity reversal simulates a single cycle of alternating current.

SPRING-CONTACT COLLARS punched out of marker body and cartridge interlock by a 1/8 in. turn of the cartridge. The cartridges are interchangeable and designed to accommodate marks 3/8 or 1/2 in. in diameter, and 1/2 by 1 1/2 in. rectangular.

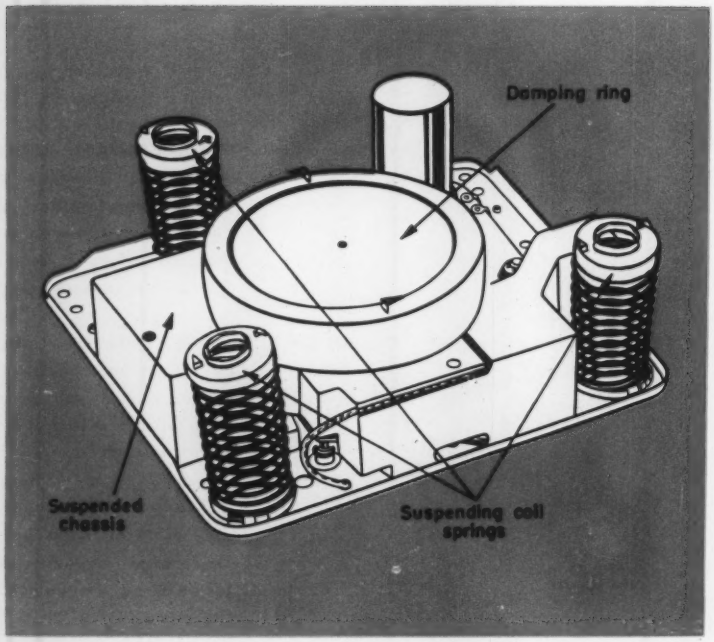
The marker is powered with ten hermetically sealed, Nicad storage batteries giving a 12-v output. Rated at 225 milliamp-hr, unit is capable of 1200 marks per battery charge. Marker is manufactured by Electroetch Co., Cleveland, Ohio.



Low-Frequency Spring Suspension Protects

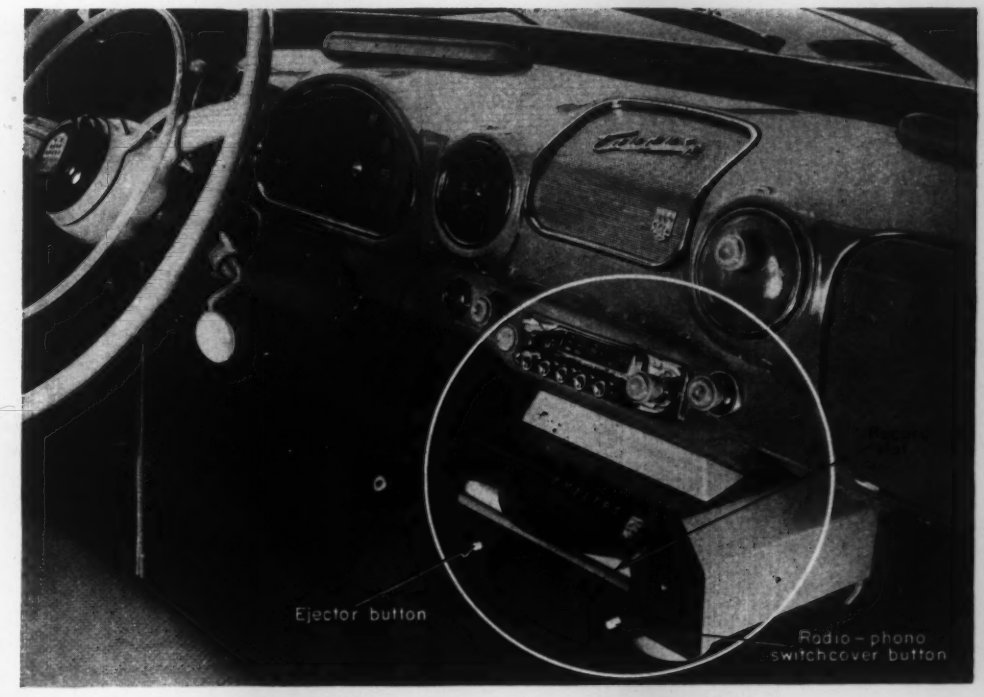


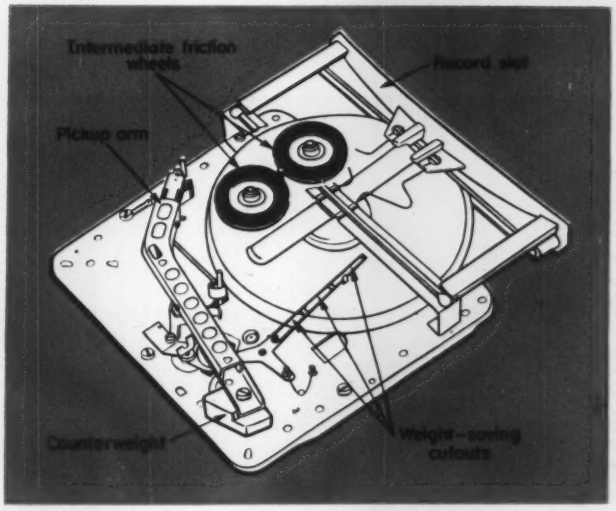
COIL-SPRING SUSPENSION SYSTEM, with relatively low natural frequency, guards an automobile-mounted automatic record player against shocks, vibrations, and centrifugal forces originating while the car is in motion. One of the three suspending springs is wound in the opposite direction to the other two to increase vertical stiffness of the suspension.



DAMPING-RING UNIT, shown in this underside view, dampens vertical vibration in the chassis. In design, the damping ring consists of two metal discs with a foam-rubber layer sandwiched in between. The center of the foam-rubber member is hollow. A built-in valve makes the unit act like an air cushion.

Car Record Player from Shocks, Vibrations



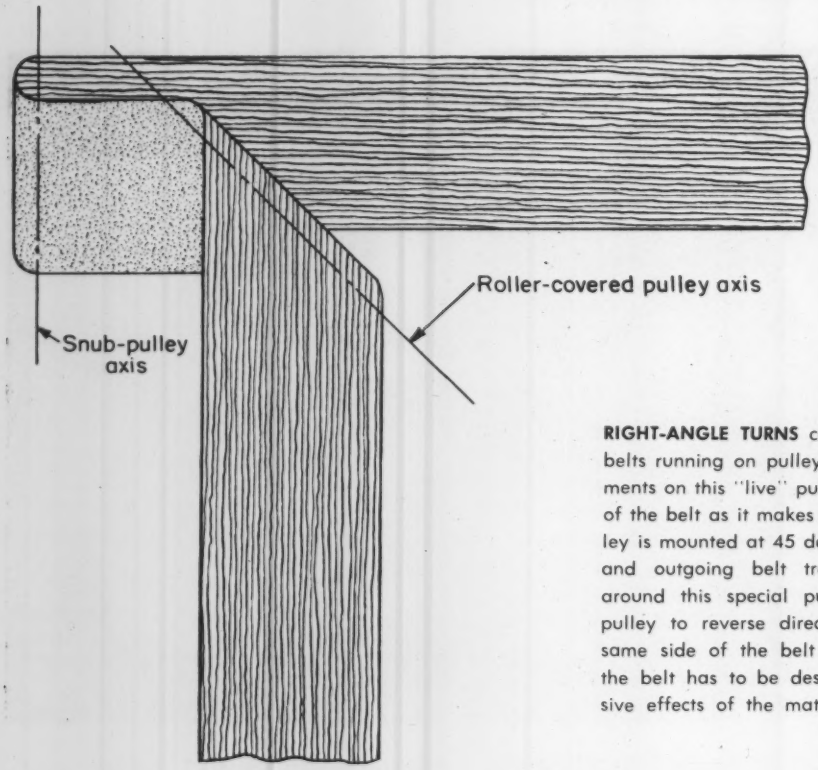


RECORD PUSHED IN SLOT operates player, which is similar in design to previous table models made by Deutsche Philips GmbH, Hamburg, Germany. A trip-pin mechanism actuates the main switch, centers the disc, lowers the pickup arm and, after playing, lifts it up, and automatically ejects the record. Ejector button has to be depressed only if the record is to be ejected before completion of cycle. Normally mounted below the dashboard, the player uses the af stage and speaker of the car's radio for sound reproduction. A pushbutton controls the changeover from radio to phonograph.

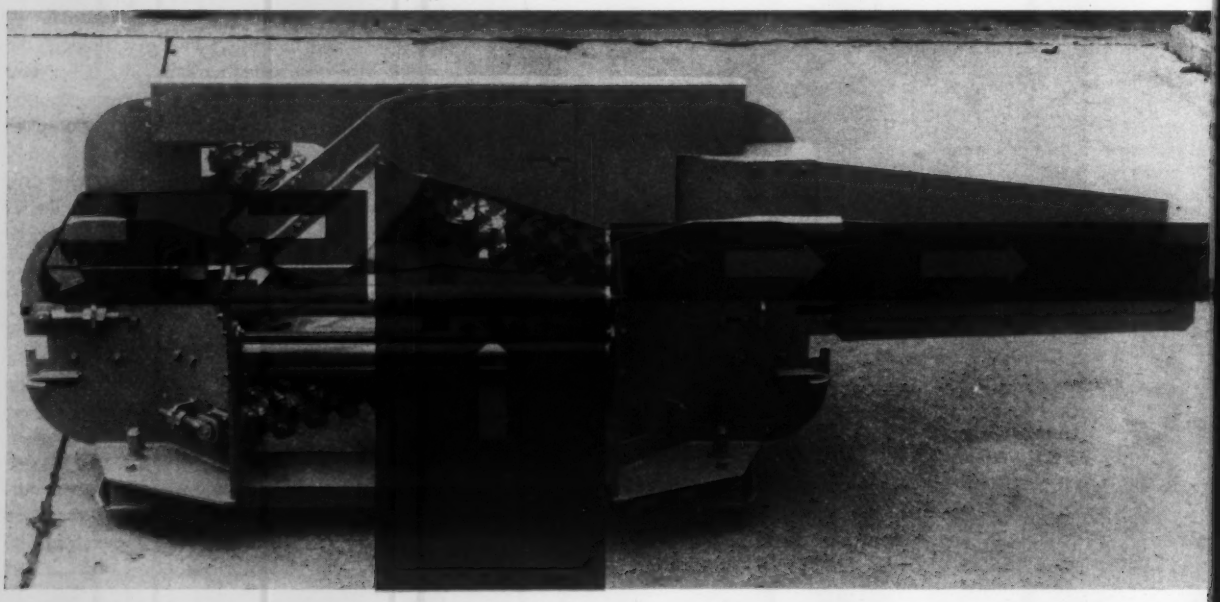
TWO INTERMEDIATE FRICTION WHEELS in the drive mechanism absorb undesirable rotary acceleration. Unit is driven by a 6-v dc motor stabilized by a centrifugal governor which holds turntable speed constant within 0.5 per cent of 45 rpm at battery voltages from 4.5 to 7.8 v. Current consumption of motor is 50 milliamp at 6 v. A built-in voltage divider permits operation on 12-v systems.

Pickup sapphire has contact pressure of less than 3/8 oz, and an adjustable counterweight permits static balancing. Frequency response of the instrument ranges from 30 to 15,000 cycles.

Flat Belt Slides Axially on

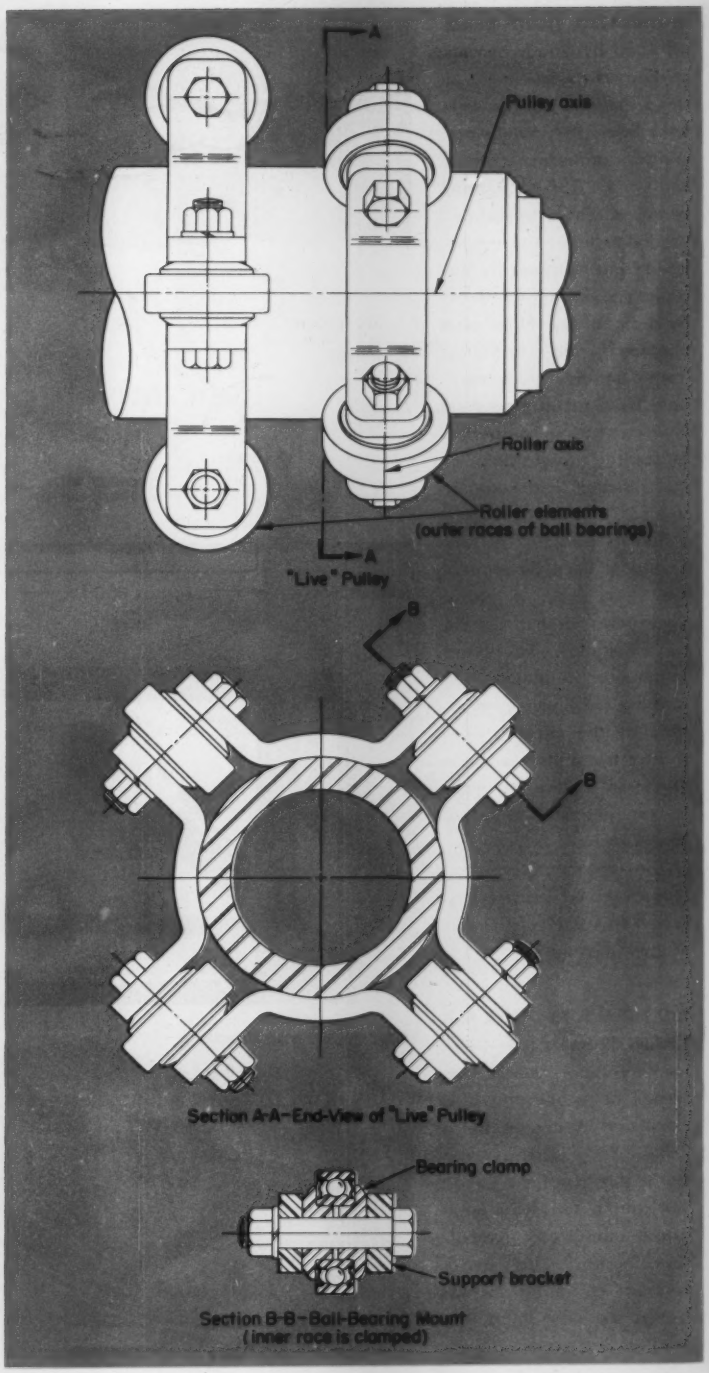


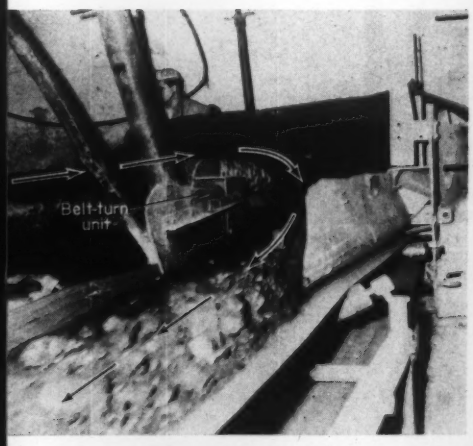
RIGHT-ANGLE TURNS can be made by flat conveyor belts running on pulleys of novel design. Roller elements on this "live" pulley permit sidewise movement of the belt as it makes a 90-deg turn. The "live" pulley is mounted at 45 deg to the direction of incoming and outgoing belt travel. After the belt wraps around this special pulley, it passes over a snub pulley to reverse direction of travel and keep the same side of the belt up. Thus, only one side of the belt has to be designed to withstand the abrasive effects of the material carried.



Special Pulley To Turn Corners

ROLLER ELEMENTS on the special pulley are simply the outer races of ball bearings. The axis of each bearing is positioned at right angles to the pulley axis. Supporting brackets clamp against the inner race of each bearing and against the body of main pulley.





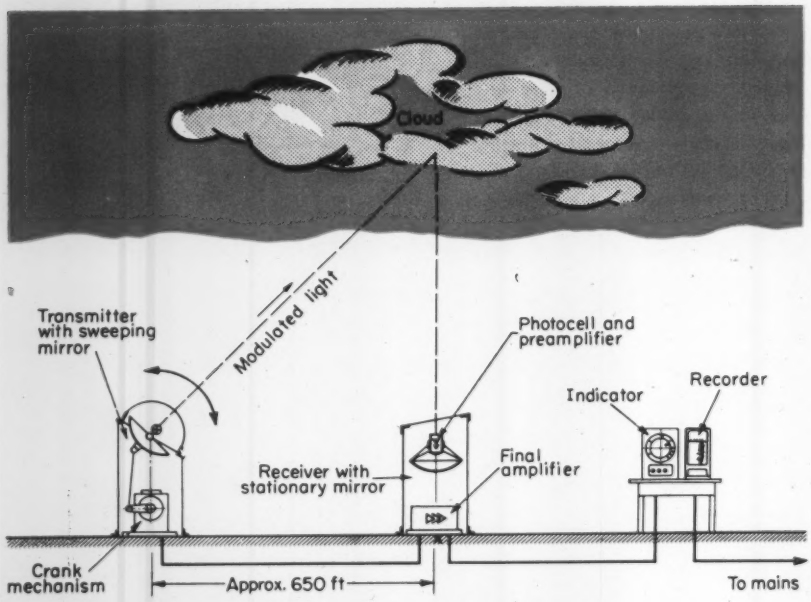
BELT-TURN ASSEMBLIES using these usual pulley designs are manufactured by Joy Mfg. Co., Pittsburgh, Pa. Application shown is in a West Virginia coal mine.

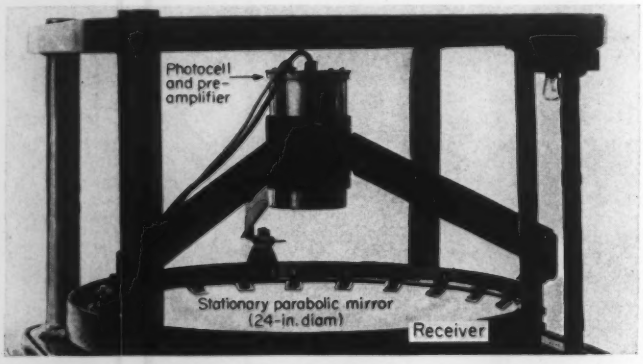
Sweeping Beam of Light Measures Cloud Heights in Daytime

MODULATED LIGHT BEAM reflected by clouds permits continuous measurement of cloud ceilings during daylight hours. A sweeping-mirror projector, which emits a 100-cps light beam, is aimed in the desired direction. The modulated light reflected by the cloud ceiling is picked up by a stationary mirror and photocell, and separated from unmodulated daylight by a tuned amplifier. Photocurrent is amplified to control signal lamp of the indicator and recorder stylus.

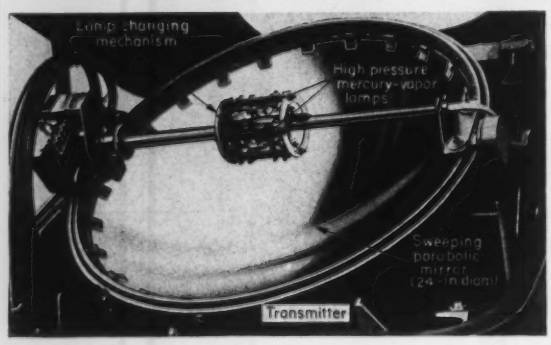
Sweep motion is imparted to the light-projecting mirror by a crank mechanism driven by an electric motor. To permit continuous readings, the rotating-field pickup actuated by the mirror sweep shaft transmits angular elevation of the projector to an indicator and recorder.

The measuring system was designed by Siemens-Schuckertwerke AG, Erlangen, Germany.





AUTOMATIC LAMP CHANGER holds four 1-kw, mercury-vapor lamps. Only one lamp operates at a time and is cooled by a built-in fan. When a lamp burns out, the lamp circuit operates a two-way relay which energizes an auxiliary motor. This motor rotates a drum which brings the next lamp into position.



Rack Planetaries

. . . unique space-saving devices for

IVAN J. GARSHELIS
Chief Engineer
Research Associates Inc.
Linden, N. J.

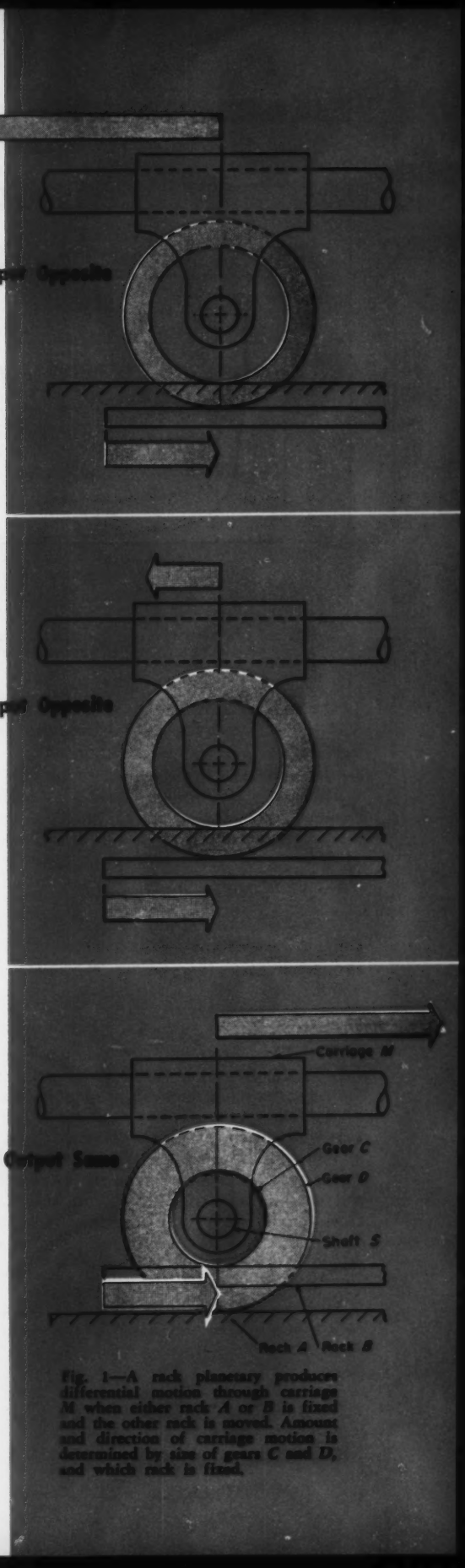


Fig. 1—A rack planetary produces differential motion through carriage M when either rack A or B is fixed and the other rack is moved. Amount and direction of carriage motion is determined by size of gears C and D, and which rack is fixed.

THE RACK planetary is a unique mechanism for obtaining large strokes from relatively small-stroke devices such as pneumatic or hydraulic cylinders and slider crank mechanisms. The gear and rack arrangement, Fig. 1, can also be used to produce reduced output motions.

Gears *C* and *D* are mounted on the same shaft, *S*, and constrained by conventional means to rotate together. Racks *A* and *B* are parallel and placed to engage with gears *D* and *C* respectively. Carriage *M*, which supports shaft *S* in bearings, is mounted with only one degree of freedom, translation parallel to the racks.

Depending on the application, either rack *A* or rack *B* is fixed with respect to the machine element on which the mechanism is mounted.

This arrangement resembles a compound planetary-gear train in which the usual sun and ring gears are replaced by racks and the planet

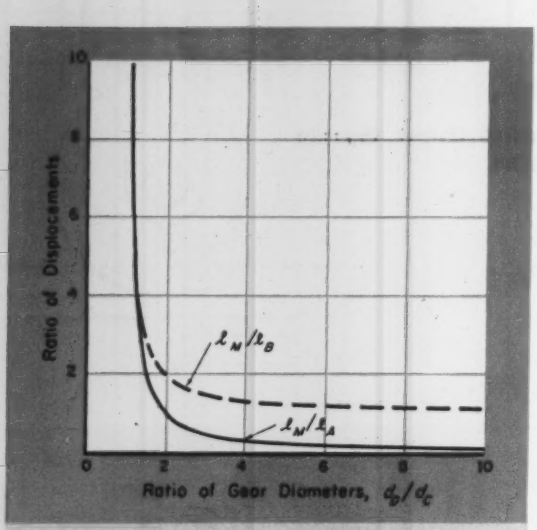


Fig. 2—Characteristics of carriage to rack displacements indicate range of application and gear diameters for desired motions.

carrier moves in a straight line.

There are three general modes of operation: 1. Reduced motion in opposite direction to applied motion. 2. Increased motion in direction of applied motion. 3. Increased motion in opposite direction to applied motion.

Opposite-Sense Output: If rack B is restrained and rack A is moved a distance l_A, the magnitude and direction of the carriage movement, l_M, is obtained from:

$$\frac{l_M}{l_A} = \frac{d_C}{d_C - d_D} \qquad (1)$$

Since d_D, the pitch diameter of gear D is greater than d_C, the pitch diameter of gear C, the resultant displacement is a negative number, which indicates a net displacement of the carriage in a direction opposite to the direction of rack A.

If gears C and D are close to the same diameter, a large ratio of carriage to rack motion is obtained. However, if gear D is many times larger than gear C, a large ratio of rack to carriage motion is obtained.

Same-Sense Output: If rack A is restrained and rack B is displaced a distance l_B, the magnitude and direction of the carriage movement is obtained from:

$$\frac{l_M}{l_B} = \frac{d_D}{d_D - d_C} \qquad (2)$$

Since d_D is larger than d_C, ratio l_M/l_B from Equation 2 is always positive, which indicates that the displacements of rack B and carriage M are in the same direction.

There is no condition for which the rack in this arrangement can move a greater distance than the carriage since the limiting ratio of rack to carriage displacement is unity, which occurs when gear D is infinitely larger than gear C. When both gears are close to the same diameter, large ratios are available from this arrangement. Fig. 2 shows the graphical representations for Equations 1 and 2.

EXAMPLE 1: Assume that rack B is restrained and rack A is moved, and that $d_D = 5$ in. and $d_C = 4.5$ in. From Equation 1

$$\frac{l_M}{l_A} = \frac{4.5}{4.5 - 5} = -9$$

Hence, carriage M moves nine times the displacement of rack A and in the opposite direction. If A is restrained and B is moved, Equation 2 gives

$$\frac{l_M}{l_B} = \frac{5}{5 - 4.5} = 10$$

Hence, carriage M moves ten times the displacement of rack B and in the same direction.

EXAMPLE 2: Assume $d_D = 5$ in. and $d_C = 1$ in. If rack B is restrained and rack A is moved, Equation 1 gives

$$\frac{l_M}{l_A} = \frac{1}{1 - 5} = -0.25$$

Hence, carriage M moves only one-fourth the displacement of rack A and in the opposite direction. If rack A is restrained and rack B is moved, Equation 2 gives

$$\frac{l_M}{l_B} = \frac{5}{5 - 1} = 1.25$$

Hence, carriage M moves 1.25 times the displacement of rack B and in the same direction.

Kinematically, the designer has only to choose the gear diameter ratio for whatever displacement ratio he requires. If exact ratios are not obtainable with integral toothed gears of the same pitch, the designer may choose gear and rack combinations of different pitches which are commensurate with strength requirements. Or, the mechanism may be complicated by the substitution of a compound gear train for the two gears used in the analysis.

In addition, the mechanism can be turned around and the carriage used to drive through the racks. This increases the applicability of the mechanism.

The only practical limitations on this mechanism are friction and rigidity. In a carefully designed mechanism, where the carriage and moving rack are rigidly supported on low-friction slides, ratios of 20 to 1 and larger can be obtained when an increase in stroke is required. In applications requiring a decrease in stroke, rigidity and control of clearances are the only limitations on the ratios obtainable.

New Property Values for VULCANIZED FIBER

R. W. WILHELM
Applications Engineer
National Vulcanized Fibre Co.
Wilmington, Del.

PROPERTIES of vulcanized fiber have, up to this time, been published only in terms of minimum and/or maximum values established by NEMA Publication VU 1-1954. As standard practice, however, data on many plastics appear as average test values. Now, for the first time, actual average test values are available for three common grades of vulcanized fiber and for a new flame-retardant grade, Pyronil. Properties data and NEMA standards, where applicable, are shown in Tables 1 and 2.

Table 1—Selected Properties of Electrical Insulation Grade*

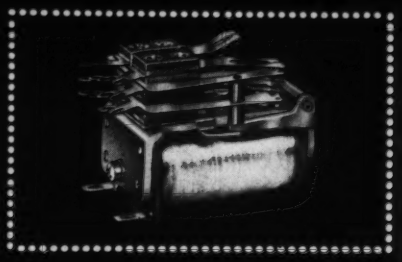
Thickness (0.001 in.)	Burst Strength (psi)		Tear Strength (longitudinal) (grams)		Tear Strength (Crosswise) (grams)		Dielectric Strength (v/mil)	
	NEMA Standard	Test Value (average)	NEMA Standard	Test Value (average)	NEMA Standard	Test Value (average)	NEMA Standard	Test Value (average)
5	75	100	100	125	120	140	—	—
10	150	200	250	300	300	335	—	—
15	225	275	375	550	450	700	—	—
20	325	400	None	610	None	800	—	—
4 to 5	—	—	—	—	—	—	200	250
5 to 15	—	—	—	—	—	—	300	350
15 to 40	—	—	—	—	—	—	250	300
40 to 125	—	—	—	—	—	—	175	200

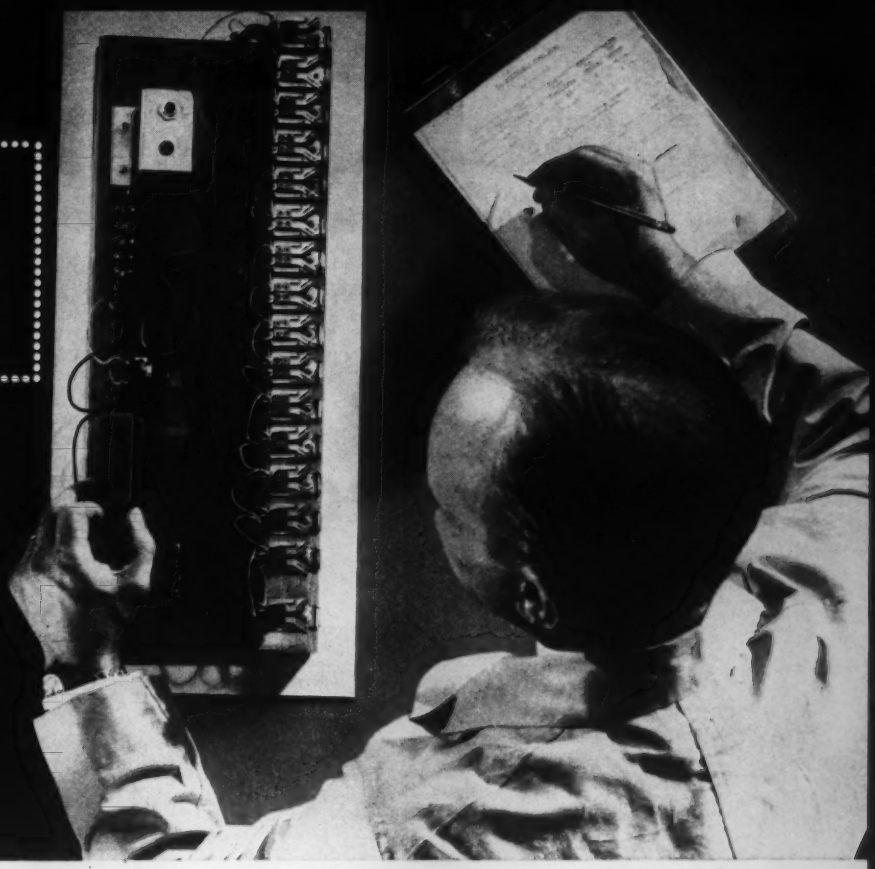
*Also see Table 2.

Table 2—Properties of Vulcanized Fiber

Property (Grade →)	Test (ASTM)	—Commercial Fiber— NEMA Standard*	Test Value (average)	——Bone Fiber—— NEMA Standard*	Test Value (average)	—Electrical Insulation— NEMA Standard*	Test Value (average)	Pyronil Test Value (average)
Mechanical								
Thickness (in.)	D374-42	1/16	1/16	1/16	1/16	1/64	1/64	1/16
Density (grams per cc)	D619-54T	1.15	1.20	1.30	1.34	1.15	1.20	1.26
Tensile strength (1000 psi),								
Lengthwise	D638-56T	8	16	8.5	17	8	21	15.2
Crosswise	D638-56T	6	9	6.5	10	6	10	7.9
Compressive strength (1000 psi),								
Flatwise	D229-49	20	26	30	34	None	†	36.5
Flexural strength (1000 psi),								
Lengthwise	D229-49	14	18	15	20	None	†	—
Crosswise	D229-49	12	15	13	16.8	None	†	—
Tensile modulus of elasticity (1,000,000 psi),								
Lengthwise	D638-56T	None	†	None	12	None	†	—
Crosswise	D638-56T	None	†	None	8	None	†	—
Bursting strength (psi)	D202-55T	None	†	None	†	—— Table 1 ——		—
Tearing strength (grams)	D689-44	None	†	None	†	—— Table 1 ——		—
Coefficient of friction,								
Fiber on fiber	—	None	0.16	None	0.16	None	0.16	—
Fiber on smooth cast iron	—	None	0.21	None	0.21	None	0.21	—
Hardness (Rockwell R)	D785-51	50	80	80	100	None	†	54
Bond strength (lb)	D952-51	None	900	None	1000	None	†	—
Electrical								
Dielectric strength, short time, (v per mil)	D229-49	175	185	175	188	—— Table 1 ——		75
Arc resistance (sec)	D495-56T	None	80	None	100	None	125	4
Physical								
Thermal conductivity (btu/hr/ft²/deg F/ft)	—	None	0.168	None	0.168	None	0.168	—
Specific heat (btu/lb/deg F)	—	None	0.403	None	0.403	None	0.403	—
Coefficient of thermal expansion (0.00001 in./in./deg F),								
Lengthwise	D696-44	None	1.1	None	1.1	None	1.1	—
Crosswise	D696-44	None	1.7	None	1.7	None	1.7	—
Heat resistance, continuous (F)§	—	None	221	None	221	None	221	221
Flammability (in. per min)	D635-56T	None	0.5	None	0.5	None	0.5	Nonburning

*Values are minimum requirements. †Property not applicable. §Determined on basis of AIEE general principles upon which temperature limits are based in the rating of electrical machinery and apparatus.





213,149,873
cycles

Test proves reliability of P&B's LS telephone type relay

These 16 LS relays, wired into a self-cycling chain, each operated 213,149,873 times before the test was discontinued. This test was made for a nationally prominent manufacturer and the certified results are available upon request.

Here is proof of the inherent reliability of P&B telephone type relays . . . and of the kind of performance you can expect when you specify them. LS relays are available with up to 20 springs (10 per stack) and are adaptable for printed circuit mounting.

Whenever multiple switching of loads up to 4 amperes is required, the LS can usually meet space, weight and—importantly—price considerations. Get full information today by calling or writing Zeke R. Smith, vice president, Engineering, or contact your nearest P&B representative.

LS ENGINEERING DATA

GENERAL:

Breakdown Voltage: 1,000 volts rms 60 cy. min. between all elements.
Ambient Temperature: —55° to +85° C.
Weight: 3 to 4 oz.
Dimensions: 1 9/32" W. x 2 3/8" L. x 1 1/2" H. (4 Form C)
Enclosures: Sealed or dust cover (W can) Sealed or dust cover, up to 6 Form C, single contacts (D can)
Mountings: Four #6-32 tapped holes 3/4" x 5/16" o.c. Other mountings available.

CONTACTS:

Arrangements: 20 springs (10 per stack) max.
Material: 1/16" dia. twin palladium. Other materials available for specific applications.
Load: 4 amps @ 115 volts 60 cy. resistive.

COIL:

Resistance: 55,000 ohms max.
Power: 65 mw DC per movable standard (50 mw possible); 3.5 watts max. at 25° C.
Voltage: Up to 200 volts DC.

TERMINALS:

Contacts: Three #18 AWG wires.
Coil: Three #20 AWG wires.
Available with octal plug, taper tabs or printed circuit pins.

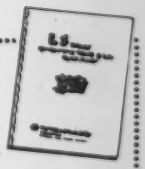
P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

TS RELAY
Short coil relay is available in AC and DC versions. Long life construction. Can be supplied (DC) with up to 20 springs (10 per stack).

GS RELAY
Excellent sensitivity: 50 mw per movable arm minimum (DC). For applications requiring many switching elements in small space.

BS RELAY
Long coil provides high sensitivity (25 mw per movable arm) and room for slugs for pull-in delays (150 milliseconds max.) or drop-out delays (600 milliseconds max.).

FREE
LS DETERMINATION DATA
Send today for booklet containing certified results of recent test described above. Data includes test circuit, interim and final measurements.



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Variable-Speed DC Drive Systems

MARK H. SLUIS
Electrical Engineer
Pratt & Whitney Co. Inc.
West Hartford, Conn.

THE three most popular methods for attaining a variable-speed dc motor drive all use a means of controlled amplification. Variation of a small signal causes a proportional change of high-level dc output. These modes of amplification are rotary, magnetic, and electronic, Fig. 1.

In considering these three methods of drive control, some relative factors that enter are reliability, maintenance, gain, speed of response, signal-power voltage, whether the device is one of low or high impedance, power range, efficiency, cost, size, and weight.

Control includes the ability to accommodate wide speed changes, acceleration, deceleration, and regulation or maintenance of speed setting under various load conditions. In a self-regulating system, gain is a measure of amplification of the error signal (deviation from set speed), whereas the speed of response is a measure of the time it takes the system to adjust itself to the new set of conditions. The two effects oppose each other, and a compromise usually must be reached. Inherently, all drives discussed are of the variable-voltage type insofar as the dc drive motor is concerned. Also, power conversion is involved since a three-phase ac supply is assumed.

Rotary Amplifiers: These are divided into three general types of devices: The basic variable-voltage drive, the armature-reaction generator, and the tuned-field generator. The most common is the Ward Leonard motor generator, or MG set, wherein a constant-speed prime mover, generally an ac motor, drives a dc generator to supply a dc motor. The generator field can be controlled by a number of schemes to exert its influence over the output voltage and power of the generator. Power applied to the control field of the generator ranges from 1 to 10 per cent of load power depending on the size of the machine. The larger the machine, the lower this percentage becomes.

Methods of controlling generator field voltage range from a hand-operated rheostat to magnetic or electronic regulating means. Regulators, in turn, could be controlled by suitable regulatory feedback signals. Total response time of several stages of amplification is proportional to the arithmetic sum of the individual time delays. On the other hand, the total gain, or amplification, of such a cascaded system would increase geometrically. By cascading until a sufficient gain reserve is available, some gain can then be traded for more rapid response by reducing coil time constants or by the introduction of feedback.

General disadvantages of the MG set are high noise level, vibration effects, and the need for planned maintenance. In addition, magnetic hysteresis in the generator iron circuit is dynamically analogous to backlash in a closed-loop servo system, and commutation effects shorten life and produce undesirable RF interference. However, the circuit facilitates the introduction of feedback signals for control or for stability with variations in load.

A popular version of the armature-reaction generator is the General Electric Amplidyne. This device combines two stages of amplification on one magnetic structure and looks much like an oversized motor or generator but combining both on one frame. The gain of such a system is quite high in comparison to a relatively slight increase in time constant over that of an MG set. By means of an armature-ex-

Announcement of Major Significance

FOR EVERY USER OF SOCKET HEAD CAP SCREWS

Following exhaustive studies begun in 1954, the socket screw products industry adopted, on April 24, 1959, new dimensional standards for socket head cap screws. Standard Screw Company participated in these studies and concurred in the recommendations approved by leading fastener manufacturers.

Adoption of the new standards, to be known as the "1960 Series", has important implications for every user of socket screws. As a public service Stanscrew will point out these implications . . . not only in relation to its own products, but also to the overall program of the industry.

Differences, Advantages Of New Design

The "1960 Series" has been carefully engineered so there is functional uniformity for all sizes, particularly as it applies to wrenching areas and to the relationship of head diameters to body diameters. For most sizes, as illustrated, this means substantial increases in both head diameter and socket size, and thus provides these advantages over the present design:

1. *Maximum utilization of the fastener's inherent strength . . . larger wrenching area permits application of greater clamping force.*
2. *Increased bearing surface under the head . . . up to 233% more.*
3. *Minimum indentation . . . particularly important with softer metals.*

Should You Convert Now?

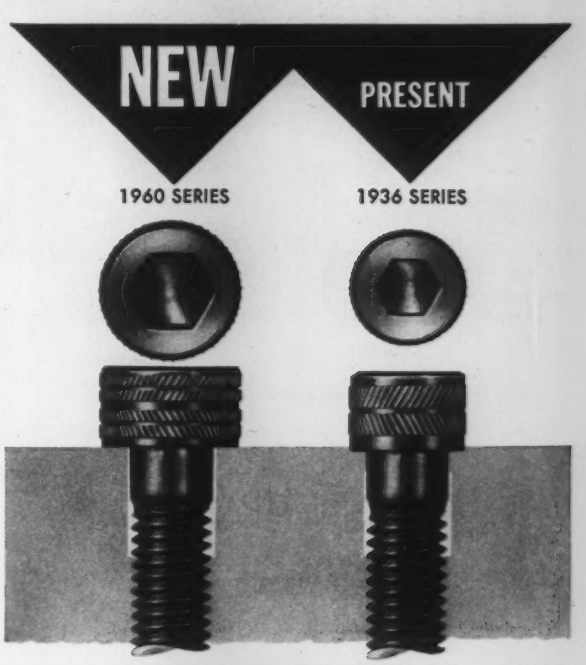
Obviously, for many applications, the new design offers important benefits which indicate conversion as rapidly as possible. In some cases, however, existing product design may not accommodate the larger heads . . . or, where socket cap screws are countersunk, revising your countersinking operations may create significant production problems. Stanscrew urges, therefore, that each company learn complete facts on the fastener industry's future plans.

Timetable For Industry Changeover

Stanscrew has already started production of the new "1960 Series". Manufacture of the present (1936) series will continue, however, and they will be available as standard, in-stock items until at least January 1, 1961. At that time, it is now contemplated the "1960 Series" will become the accepted standard throughout industry and the "1936 Series" will then be furnished only when specifically ordered.

When Designing A New Model

For products now on the drawing board, this timetable indicates many manufacturers should plan to use the "1960 Series" as the standard for later production. By making such design provisions, you assure maximum acceptance and minimum difficulty in the future.



For Existing Products

For many existing applications, where socket cap screws are not countersunk, either the 1936 or the "1960 Series" may be used. In frequent cases, improvements of the 1960 design suggest conversion within a short period. In other applications, where the heads are countersunk or where the greater head diameters of the "1960 Series" create a problem, changeover should probably be postponed until a general redesign of your product is scheduled.

Special Stanscrew Marking

To further distinguish its "1960 Series", Stanscrew will knurl heads of all new style socket cap screws with a split herringbone design (as shown). This special marking and the new "1960 Series" box labeling will provide quick identification of these quality fasteners.

For Further Information

Your Stanscrew distributor has the latest facts on the new "1960 Series" and will be happy to discuss them with you. If desired, he also will arrange for a prompt visit from a Stanscrew fastener specialist who will be most happy to go over all aspects of this new industry program as it regards your own particular operation.

Stanscrew also has a new brochure which provides complete dimensional and design data on the "1960 Series". No obligation, of course, for your copy.

STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

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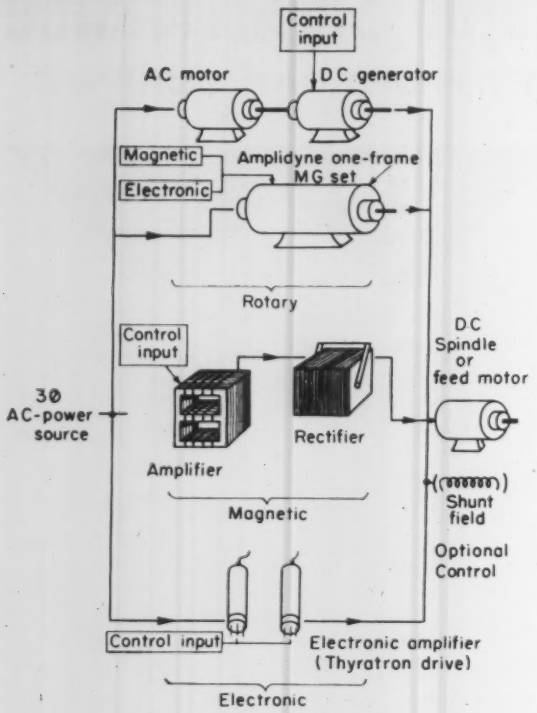


Fig. 1—Three methods of dc motor control.

Table 1—Ratings of DC-Drive Systems*

System→	Magnetic	Rotary	Electronic
Size and weight	2	3	1
Efficiency	1	3	2
Power range	2	1	3
Reliability	1	3	2
Response speed	2	3	1
Cost	1	2	3
Speed range	3	2	1
Maintenance	1	3	2

*Lowest number is most desirable.

citation method, the same magnetic structure of the Amplidyne is utilized twice, comparing favorably to the function of two cascaded generators.

As in the case of the MG set, in some applications electronic or magnetic preamplification may be used as a regulating or stabilizing feedback input. It is important to note that the reaction generator is an excellent regulatory device in itself. The Amplidyne, therefore, has a built-in feature which, in its degree of performance, is in some other systems available only as an accessory.

The third type of rotary amplifying device, the tuned-field generator, is comparable with the Amplidyne in most applications. The tuned-field generator is a relatively simple modification of a conventional dc generator and includes a critically adjusted field for self-excitation as well as one or more control fields. Tuning refers to adjustment of resistance in the self-excited field circuit.

Magnetic Amplifiers: Like the thyratron system, the magnetic amplifier operates as a synchronous switch oscillating at a power-line frequency with the load connected to ac power whenever the "contacts" are closed. Instantaneous impedance of the reactor drops abruptly at some preset instant and restores when the line voltage passes through zero.

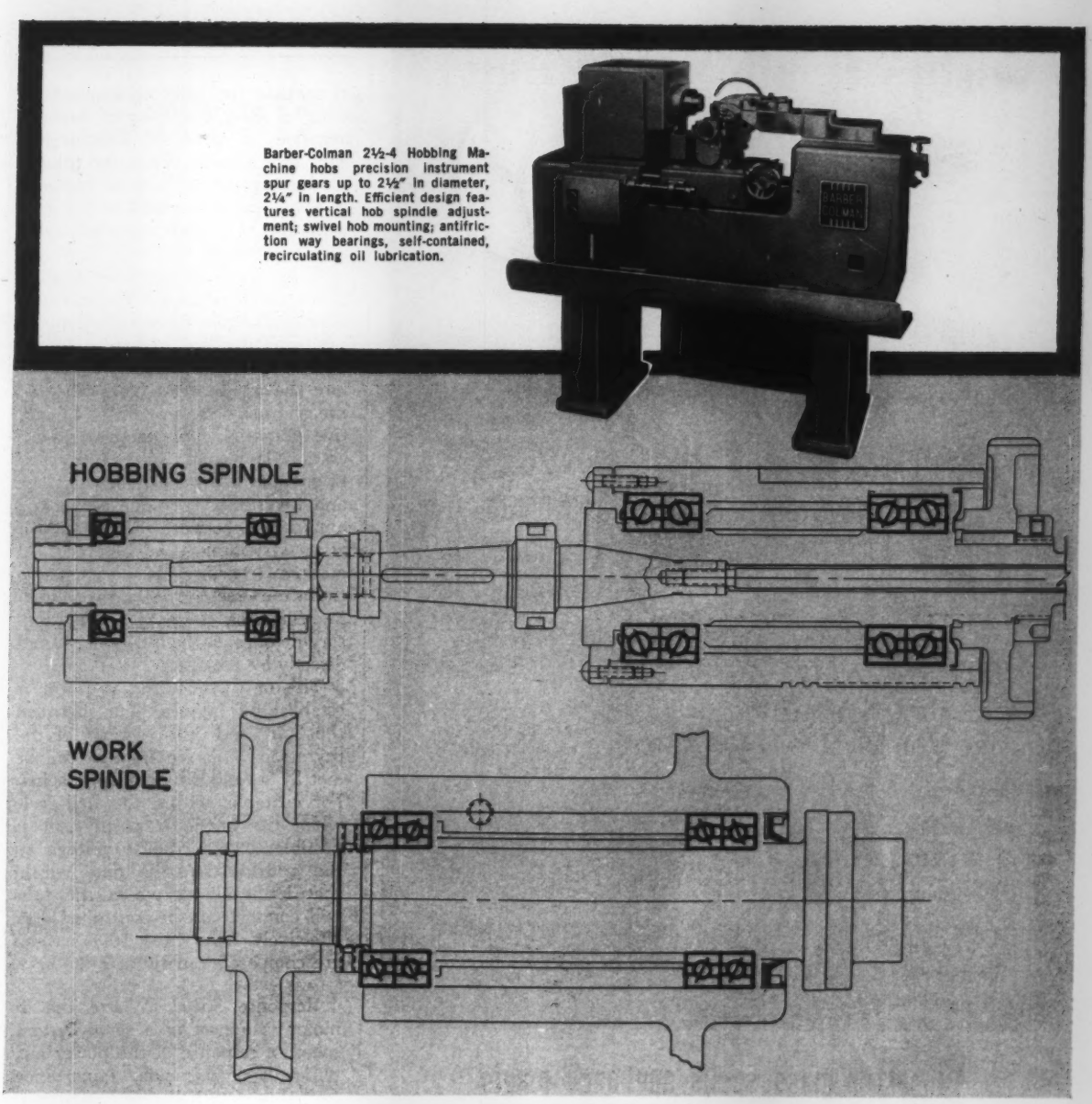
Until recently, a magnetic amplifier, or saturable reactor, was used to drive only low-power motors. A common application also was as a regulatory device in the adjustable voltage of an MG-set control system. Use of a magnetic amplifier provides a versatile means of feedback information that can incorporate *IR*-drop compensation, anti-hunt speed regulation, and current-limiting features, to name a few. More recently, magnetic amplifying systems incorporating the necessary rectification have been made available to control dc motors of up to 200-hp output.

Although the magnetic amplifier is the most recent device for controlling dc motor speeds, it already has created much interest because it is completely "static."

Electronic Amplifiers: These are also referred to as thyratron drive systems. The thyratron is a three-element gaseous tube which can be made to act much like a switch. It can be turned on or off to become conducting or nonconducting depending on the conditions existing in the three-element relationship.

The tube requires some warm-up time, a disadvantage in some applications. When potentials are applied to both plate and grid so as to make them positive in relationship to the cathode, the thyratron will conduct. Since the grid draws only a weak current, powerwise, positive potential applied to this element can, in turn, control large amounts of current in the form of electrons proceeding from the cathode to the anode of the tube.

Once turned on, the only means



Barber-Colman 2½-4 Hobbing Machine hobs precision instrument spur gears up to 2½" in diameter, 2¼" in length. Efficient design features vertical hob spindle adjustment; swivel hob mounting; antifriction way bearings, self-contained, recirculating oil lubrication.

Relative rotation of hobbing machine spindles held accurate within 20 seconds using Fafnir Ball Bearings

New Barber-Colman 2½-4 machine precision-hobs spur gears for instruments

If two words can sum up the design of Barber-Colman's new 2½-4 Hobbing Machine, they are *accuracy* and *rigidity*.

Developed for hobbing AGMA Precision Class 3 fine-pitch spur gears for guidance systems, the 2½-4 has a minimum number of parts at points where deflection or inaccuracies might occur.

In selecting bearings which would complement the accuracy of the gears in the machine, Barber-Colman designers got the performance they wanted with Fafnir super-precision ball bearings. Single row, extra-light, counter-bore types, eight used in duplex pairs, help maintain indexing accuracy within *20 seconds*.

The application is typical of thousands Fafnir has handled where performance requirements put an extra premium on bearing selection. Chances are, Fafnir experience — plus breadth of line — can answer bearing problems you may have. Write The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR
BALL BEARINGS

10 Fafnir Extra-Light Super-Precision Ball Bearings, snug fit, support the Barber-Colman 2½-4 machine spindles. 4 variations, equipped with composition retainers, are available in this one series to meet specific load and speed requirements where exceptional rigidity is wanted.

Circle 509 on Page 19

Lancaster glass spells appliance magic

For appliance manufacturers, Lancaster glass parts offer a bright new world of opportunity. Whatever your product or problem, Lancaster can provide functional and decorative glass components custom-made to your exact specification. Let us show you how Lancaster craftsmanship can give your appliance extra beauty and utility that will pay off in extra sales. Send blueprints, or write to Lancaster Glass Corporation, Lancaster 2, Ohio. Telephone OLive 3-0311.

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of making the tube nonconducting is to let the plate or anode become negative in potential relationship with the cathode. While the tube is conducting, no amount of increase or reduction of potential on the grid will affect the rather one-track abilities of the tube.

When an ac potential is applied to the anode of such a device, every other half cycle presents an opportunity to turn off conduction of the tube and keep it turned off if, before the anode again goes positive, the grid has been brought to a negative potential. This method of operation is termed automatic resetting. By utilizing two tubes together and inverting the anode ac voltage application between tubes, a full-wave system may be obtained. In addition to acting like a switch, the thyratron rectifies while conducting. This feature gives it the necessary dc output which can be utilized directly by a motor.

The only remaining problem is establishing elapsed time between the "on" and "off" periods of the thyratron. This requirement can be met by several different approaches. For example, within the half-cycle when the anode is positive, it is possible to alter the ac voltage on the grid so that the time within that half-cycle at which the tube will conduct can be controlled very effectively. The three drive systems are compared generally in Table 1.

Response Speed: Where the dc motor is a part of a servo system, speed of response of the power amplifier is of particular importance. Probably more accurate and truer to form than speed of response, a factor or figure of merit called the "power gain per cycle" is often given. In magnetic amplifiers, for instance, speed of response can be improved, within limits, at the expense of a decrease in power gain and vice versa.

In a thyratron system, power gain can be increased without decreasing the speed of response by using larger tubes and auxiliary control.

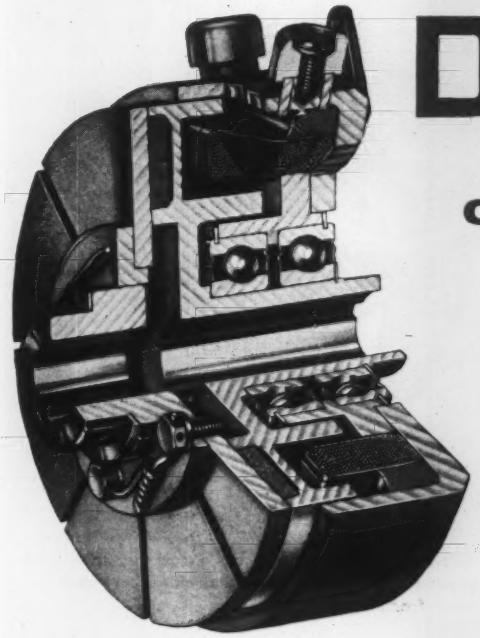
Unquestionably, the Amplidyne has the most rapid response characteristics of the rotary drives. Rotary amplifiers, however, have the slowest response characteristics of the three systems mentioned. Uncom-

Circle 510 on Page 19

Small Units for Big Jobs!

EATON DYNA-TORQ

MAGNETIC-FRICTION CLUTCHES and BRAKES



STATIONARY-FIELD, BEARING-MOUNTED DYNA-TORQ CLUTCH

Now Available in a Full Line from 1¾" to 15" Diameter

Eaton Dyna-torQ Magnetic-Friction Clutches and Brakes provide a simple, accurate, responsive method of controlling power and motion in today's complex production and processing machines.

The smaller sizes and advanced design types of Dyna-torQ Stationary-Field Clutches and Brakes enable Eaton to offer a well rounded line, including flange-mounted and bearing-mounted clutches, and replaceable-face brakes. Unique features of design and construction result in worthwhile maintenance cost savings. Dyna-torQ units, easily and quickly installed on new machines or existing plant equipment, deliver many highly desirable advantages.

Dyna-torQ Magnetic-Friction Equipment Offers these Important Advantages:

- ★ Accurate power control
- ★ Dependable motion control
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- ★ Inter-changeability of parts

Send for this illustrated bulletin giving complete description and specifications covering Dyna-torQ Stationary-Field Clutches and Replaceable-Face Brakes.

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Dyna-torQ Equipment is Available through Dynamatic Distributors in all Leading Cities

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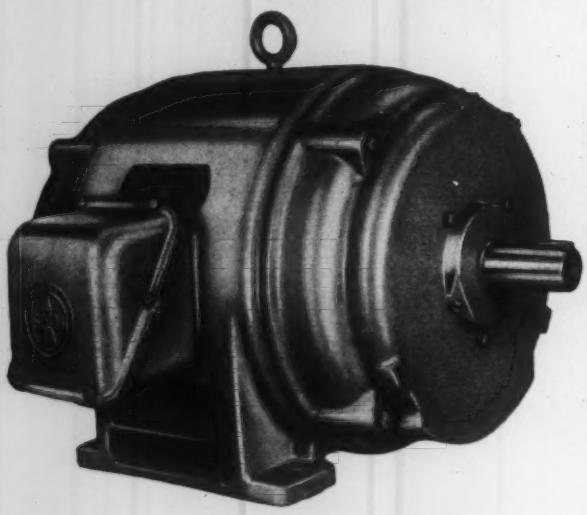
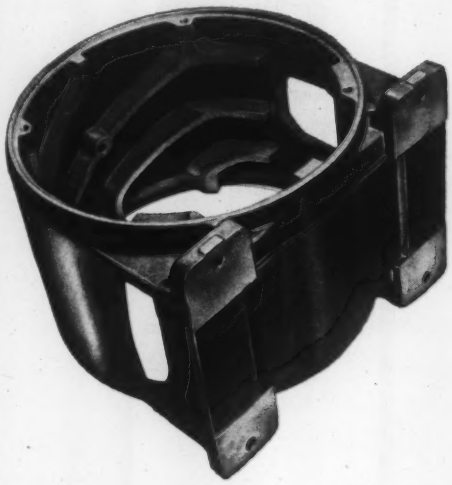


Spiro-duct double-end system: In standard motor shown, air enters shaft end and discharges between feet on conduit box side of motor. Conversely, air entering free end discharges opposite conduit box. In motor with conduit box located opposite to standard position, direction of air flow is reversed in relation to drive shaft location.



Spiro-duct moves cooling air in clockwise spiral direction, through space between stator core and motor frame.

Cools entire core and winding regardless of direction of rotation!

From the research and development laboratories of Fairbanks-Morse comes Spiro-duct cooling—the most effective design available for positive cooling of Dripproof motors—available now in F-M rerated KZK motors, in frames 364U through 445U.

Two completely independent paths for cooling air are provided in the Spiro-duct double-end system. All portions of the stator core and winding are thus assured equal cooling, regardless of direction of rotation.

With completely redesigned and improved enclosure as well as ventilating system, Fairbanks-Morse offers an exceptionally cool motor with maximum protection against falling particles or dripping liquids.

For expert assistance in specifying, write Fairbanks, Morse & Co., 600 South Michigan Ave., Chicago 5, Illinois. Fairbanks-Morse motors include all types in alternating and direct current, in ratings from ½ to 10,000 HP.

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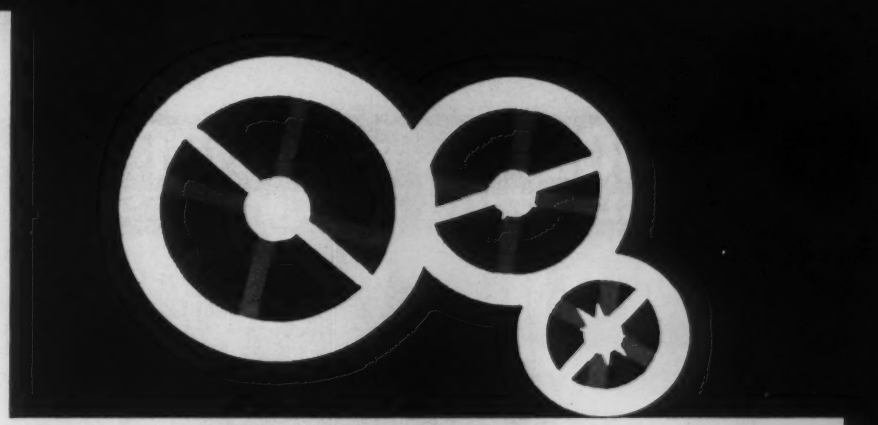
pensated response times of up to 1 sec or more are not uncommon in MG-set application. Compare this to the thyratron's ability to respond to a signal change within ½ cycle, which in the case of 60 cps power supply would be only 8 millisec. Minimum response time of the magnetic amplifier is about 1 to 2 cycles of the supply frequency.

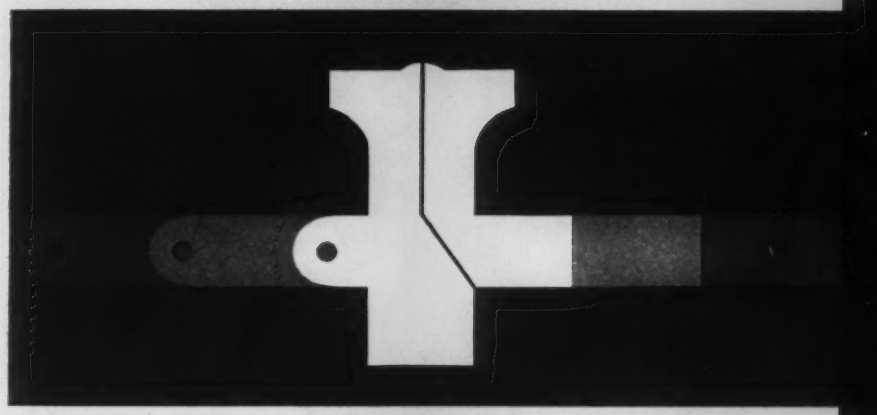
Reliability: When reliability of the drive is of utmost importance, the magnetic amplifier has advantages over the other two systems. Amount of heat dissipation within such a system is a minimum and can be removed easily by minimal cooling efforts. The reactor and rectifier components are of unquestionable reliability. Their utmost performance can be doubly insured by utilizing them below their rated capacities.

Concerning rotary machines, a primary source of maintenance difficulty is commutator brushes. Other liabilities are a need for adequate cooling and cleanliness of ventilation as well as periodic lubrication of the bearings. Accumulation of dirt in commutator segments can cause a gradual decrease in over-all gain of the reaction generator and require a shop overhaul to correct the condition.

In contrast to the tubes found in home radio and television sets and other home equipment, industrial tubes are especially constructed to meet severe requirements and have extreme reliability. It is quite common for an industrial tube to have a life of 10,000 hr. A thyratron system, therefore, although containing probably several of these "receiver-type" tubes can and will remain reliable for long periods of time. With proper preventive maintenance, downtime can be eliminated almost completely.

Power Range: The next basis for comparative analysis might be termed power range under which category is included load characteristics. Horsepower output of a motor is proportional to the product of speed and torque. When the speed is changed, either the horsepower or torque, or both, must be changed. In drives, a constant horsepower is possibly more suitable. Each of the three control packages





A CHALLENGE TO DESIGNERS—Should you be the type of individual who can cast off the tried and true concepts of motion control, there are great rewards for you in the application of Reid rotary, linear and quadrant controls. Such gems as the elimination of hunting conditions and compensating components in servo-systems, positive valve positioning with less actuating power, fail-safe rotary and linear actuators, simpler and more efficient gear trains, no-slip ball screws and hundreds of other prize winners. It's all done mechanically, with definite predictability. Of course, they can be motor, solenoid, hydraulic, pneumatic or manually operated. Any man who thinks for himself wouldn't dare pass up our provocative brochure.

REID CONTROLS
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SINGLY or by the HUNDRED
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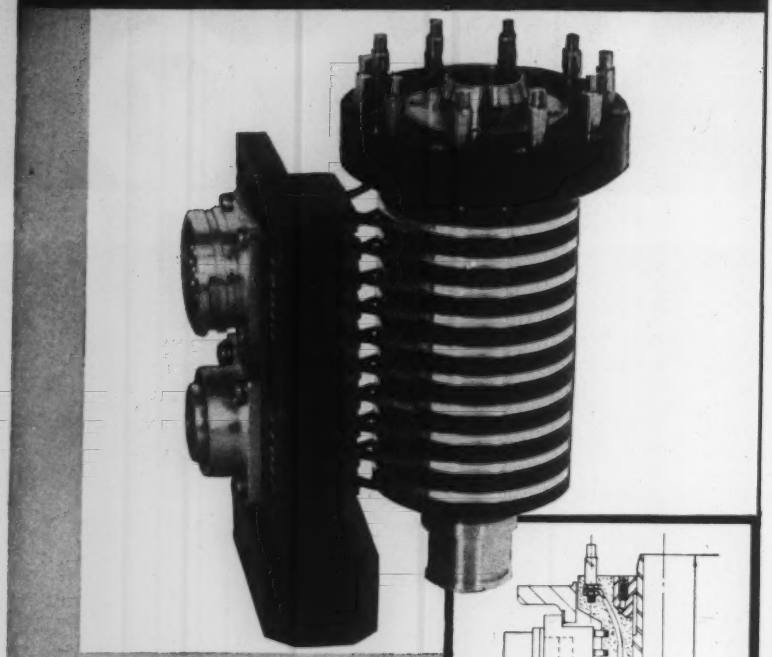
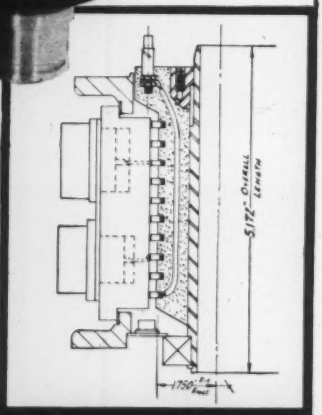


This slip ring assembly, 5¼" high and 3" dia., has 10 silver rings. Brushes are silver graphite.



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Every Superior slip ring assembly is "cut and tailored" to individual requirements; *is delivered complete*. One technical staff directs *all* steps toward your product's end use. Brush grades are carefully selected for minimum noise level and long life of both rings and brushes. Atmospheric conditions are studied in laboratory and field. Result: Superior slip ring assemblies deliver optimum performance consistent with your insulation specifications and available space . . . TYPICAL APPLICATIONS: *signal circuits, power circuits, segmented commutators, special brush blocks, combination signal and power circuits.*

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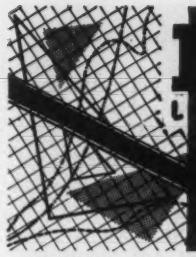
has some flexibility in this area. It is best to be aware of this requirement at the outset, since some of the commercially available equipment is limited in its ability to give required output characteristics. Controlling the armature voltage of the driven motor gives a constant-torque relationship for a certain speed range. Additional range at higher speed and constant horsepower results by control of the shunt field.

With regard to cost, size, or any other comparative quantity, the available power of the magnetic amplifier ranges from fractional horsepowers up to 200 or more. The motor-generator drive is available in a range from 3 to 200 hp. Electronic control offered by thyratron drives is readily available from low fractional-horsepower range to a top limit of 40 hp.

Efficiency: When considering any electromechanical system, it is always wise to consider the number of energy changes involved between input and output. For such an analysis it is necessary to refer to a common power source such as available three-phase, ac input. The most efficient of the drive systems under discussion is probably the magnetic amplifier which utilizes the more recently developed high-efficiency semiconductors for rectification of its output. The second in rank is electronic means of control which dissipates a fair amount of energy in the form of heat. To some degree the efficiency of this system is a function of the firing time of the tubes and, hence, speed of the output device.

Mechanical rotary-amplification schemes in general are a great deal less efficient. Consider, for instance, the motor-generator system. Three energy changes are required: From electrical to mechanical, mechanical to electrical and, again in the dc drive motor, electrical to mechanical. This sort of system cannot be very efficient. In general, all of these packages range from 60 to 90 per cent efficiency. The specific amount is largely dependent upon the power range and the particular speed.

Cost: In the fractional and small horsepower ranges, the thyratron-



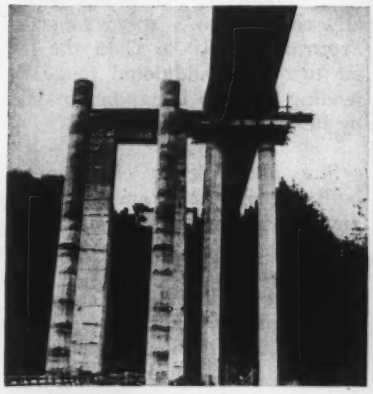
MOLYKOTE® LUBRICANT DESIGN news

GERMAN ENGINEERS USE MOLYKOTE TO SLIDE 944 FOOT BRIDGE 60 FEET

The relocation of a bridge of these dimensions without the use of rollers has not previously been reported. The weight of the bridge was approximately 4,500 tons.

The results of extensive testing at the Bavarian Testing Institute at Nurenberg showed it to be more economical to move this bridge on girders lubricated with MOLYKOTE Type G than on rollers.

When writing refer to Item 503.



This bridge carries traffic of the Munich-Salzburg Highway over the Mangfall Valley.

MOLYKOTE® OPERATES EFFECTIVELY OVER -300°F. TO 750°F. TEMPERATURE RANGE

ATOMIC RADIATION DOES NOT AFFECT MOLYKOTE TYPE Z

Extreme temperatures rule out the use of conventional lubricants. They freeze solid at extremely low temperatures or form objectionable deposits at elevated temperatures.

The missile age has further complicated lubrication problems. Not only must lubricants operate over a wide temperature range, but they must be unaffected by radiation, be capable of functioning in a vacuum, be compatible with liquid oxygen, and have indefinite storage life.

MOLYKOTE Type Z meets all of these requirements and is the only lubricant known to operate over a 1050°F. temperature range (-300° to 750°F.). In inert atmospheres, MOLYKOTE Type Z is unaffected by temperatures as high as 2000°F.

MOLYKOTE assures nearly 100% protection against galling and seizing on all low velocity extreme bearing pressure applications. With MOLYKOTE, the coefficient of friction decreases with increased loads and there is no tendency for it to be wiped away. The coefficient of friction with MOLYKOTE Type Z is .024 at 400,000 psi. MOLYKOTE maintains its effectiveness in the presence of all but a few strong acids. The problem of lubrication where abrasive dust contaminates the atmosphere is greatly reduced by MOLYKOTE dry films. MOLYKOTE Type Z conforms to MIL-M-7866A (ASG). It is the basic ingredient in the many MOLYKOTE types that are available to industry.

When writing refer to Item 501.

NEW MOLYKOTE "WEAR IN" COMPOUND REDUCES SURFACE DAMAGE RESEARCH PROVES

During the critical wear in period, permanent surface damage, variously described as "galling", "scuffing", "scoring", "tearing", "scratching", "excessive abrasion", and "seizing", is an inherent hazard.

Cross section of ground steel surface. (Redrawn to scale.)

When magnified, even highly polished metals show surface irregularities as in the drawing above.

MOLYKOTE "Wear In" Compound was developed as a result of extensive research. It drastically reduces the time necessary to accomplish wear in and eliminates the hazards.

"Wear In" damage requires costly reconditioning of new equipment and the amount of damage left unrepaired has much to do with the useful service life of machinery.

When writing refer to Item 502.

LIFETIME LUBRICATION WITH MOLYKOTE BONDED COATINGS

MOLYKOTE resin bonded lubricant coatings combine all the outstanding characteristics of MOLYKOTE with today's most advanced air-drying and thermosetting resins.

Roller Bearing Company, W. Trenton, N. J., process self-aligning bushings with a MOLYKOTE resin bonded coating. This coating provides lifetime lubrication and protection against corrosion.

MOLYKOTE resin bonded lubricant coatings are an amazing new development in the field of lubrication. They provide bearing surfaces with a wear-resistant film that has a low coefficient of friction. In many cases, the initial treatment is sufficient to lubricate parts for the lifetime of the equipment.

When writing refer to Item 504.

Self-aligning bushing manufactured by Roller Bearing Corporation of America, W. Trenton, N. J.

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Stamford, Conn.
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Item 501 ☐ Item 502 ☐
Item 503 ☐ Item 504 ☐

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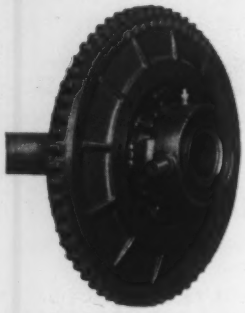

This Over-Center *Cut-off* Clutch has minimum overall length for restricted space applications. All of our over-center clutches are readily adjusted for wear by releasing latch and turning toggle assembly.

Our standard line includes also air-operated clutches. We invite inquiries for *standard* or special clutches. Write us at Box 118, Waukesha, Wisconsin or telephone LIberty 7-3359.

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Waukesha Wisconsin

Circle 516 on Page 19

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Circle 517 on Page 19

type control in most applications is the most economical. From 5 hp and up, the thyratron drives become slightly more expensive than the motor-generator and magnetic-amplifier type devices. From 10 to 200 hp, the magnetic amplifier and motor-generator set are identically priced by at least one of the big equipment venders. Topping all is the Amplidyne, exceeding the cost of the other modes by a considerable percentage in most cases.

Speed Range: Thyratron drives are commonly available with a 50 to 1 range with possible extension to as high as 100 to 1 for special applications. An 8 to 1 ratio can be obtained from available magnetic-amplifying equipment, whereas motor-generator type control is generally confined to a speed range of approximately 10 to 1. In the latter two cases, additional range extending to 30 to 1 may be obtained by field control of the motor.

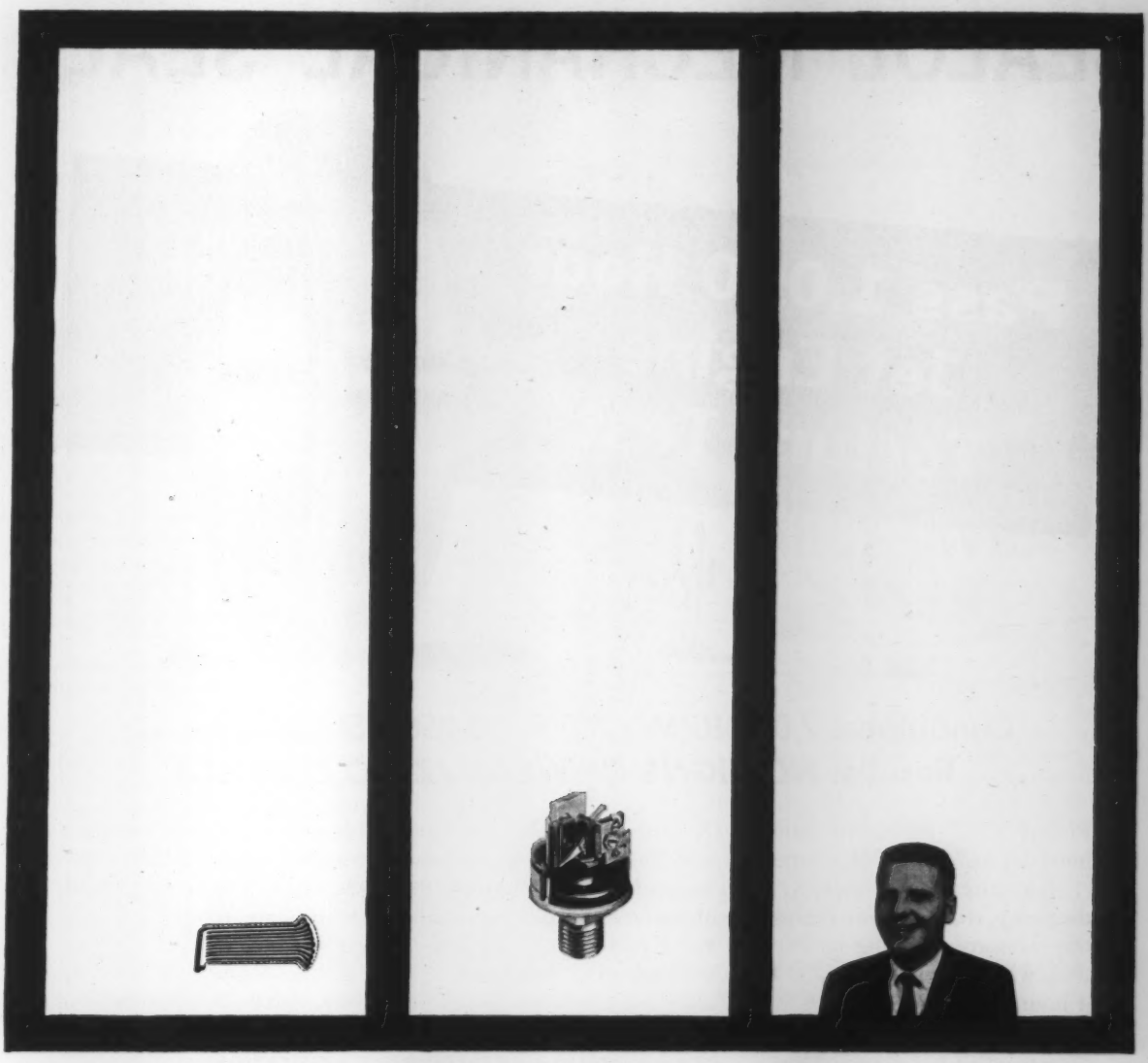
Size and Weight: In general, both the electronic and magnetic-amplification systems are more flexible to the extent that they can be integrated with other controls for a particular application. Rotary devices require some consideration as to appropriate mounting keeping in mind vibration and noise problems. In most instances, weight of the rotary amplifier far exceeds that of its contemporaries.

ASME paper 59-MD-3, Design Engineering Conference, Philadelphia, 1959; 8 pp.

Resistance Welding of Sheet Steel

G. E. GROTKE and W. D. DOTY, United States Steel Corp.

BASIC types of resistance-welding processes are spot welding, seam welding, projection welding, upset-butt welding, and flash welding. Seam welding and projection welding are essentially special cases of the spot-welding process. All types of low-carbon steel sheets are readily weldable by these processes. However, although welding characteristics of the low-carbon steels are



Tiny Living Heat Exchangers. Some species of deep sea fish have countercurrent bundles of blood vessels (rete mirabile, shown twice actual size) so efficient that if boiling water and ice water were counterflowing in them, heat transfer would be complete to 1/10,000 of a degree!

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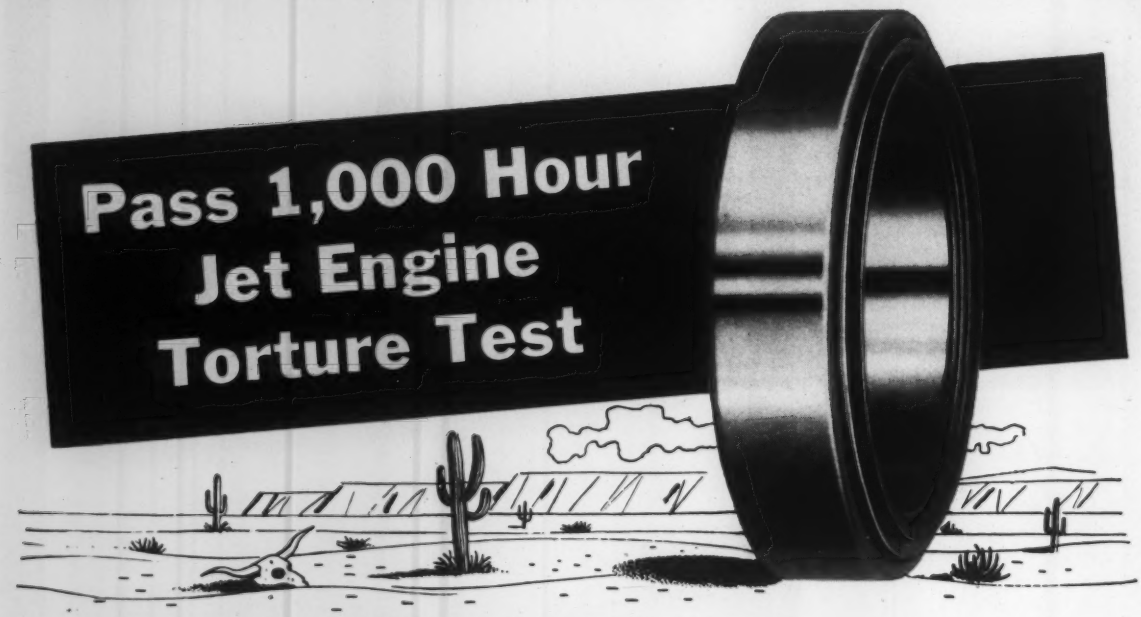
SEALOL MECHANICAL SEALS



Conditions: 7,000 RPM 250°F. 0-250 PSI cycling pressures

Results: *NO SIGNS OF WEAR – ZERO LEAKAGE*

Picture a ¾" jet engine pump shaft running bone dry at 7,000 RPM, temperatures to 250°F. . . . hour after hour. Suddenly, water surges into the pump, slams into the shaft seal with momentary pressures running to 650 PSI. For 2 minutes, water is pumped at 250 PSI, then back to 4 hours of dry running.

After one thousand hours of continuous service, the seals showed no signs of wear . . . zero leakage during the water cycle. The secret behind this outstanding performance record is in the special "one-thirteen" treatment given the carbon faces.

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RPM	Shaft Size	Temperature	Fluid	Pressure
51,000	1 3/16"	400°F	Peroxide steam and nitrogen	0-10PSI
17,000	3"	225°F	Air Oil Mist	2-3PSI
37,500	1"	650°F	Mil-O-5606	20-30PSI
13,800	1 11/16"	—300°F	LOX	50PSI
3,500	1⅜"	270°F	Acetone, H2S04 and Phenol	80PSI
1,750	1⅞"	100°F	Mercury with 5% water	160PSI
173	1"	210°F	Tomato products	30PSI
25	1¼"	Ambient	Heavy Water	150PSI

YOUR PARTICULAR SEALING PROBLEMS

. . . may or may not call for "one thirteen" treated seals . . . or welded metal bellows seals . . . or heavy duty Flexibox-type seals . . . or low cost RS seals.

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similar, they are by no means identical. Differences in the resistance-welding characteristics of low-carbon steel sheets are not due to poor weldability of the steel but mainly to improper adjustment of welding conditions. This review establishes why such incompatibility between welding conditions and different sheet steels is to be expected.

Heat Generation: Heat generated in a workpiece depends on the magnitude of welding current, resistance of the current-conducting path, and the time that the current is permitted to flow. Resistance-welding equipment permits precise and consistent control of the current magnitude and time of current application. Resistance is not directly controlled by the welding-machine operator. Magnitude of electrical resistance of the material between the electrodes depends on the physical characteristics and thickness of the material welded and, for a given material, can be considered constant if contact conditions are in accordance with good practice. Therefore, resistance directly influences current, electrode force, and weld-time settings. Adjustment of these settings may be required to compensate for variations in resistance of different steel sheets.

Carbon Content and Resistivity: Electrical resistivity of carbon steel increases with increased carbon content. In the range from 0.03 to 0.12 per cent carbon, which includes the bulk of all low-carbon sheet, strip, and thin-plate production, electrical resistivity increases approximately 40 per cent. Further increase in carbon above 0.12 per cent results in continued increase in resistivity but at a much less rapid rate.

It follows then, that significant differences in the amount of heat generated in forming a resistance weld result if the same welding conditions are employed to weld sheets of markedly different resistivity. Welding-machine settings established for low-resistance steel sheets must use high current to generate sufficient heat to form an adequate weld nugget. If the same settings were used with higher-carbon, high-resistance sheet steels, excessive electrode indentation and weld-metal

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ALLEN HEX-SOCKET SCREWS HEAD

Circle 520 on Page 19

expulsion could be anticipated. Conversely, welder settings that are satisfactory for high-resistance sheets may produce welds of insufficient size and strength if the same schedules are used for lower-resistance materials.

Strength: Mechanical properties of low-carbon steel sheets are influenced by chemical composition of the steel and by rolling practice and heat treatment used for producing the sheet. Higher carbon contents and mechanical working below the recrystallization temperature contribute to increase strength and hardness. Hot-rolled steel sheets may often exhibit some degree of strengthening because of cold work.

Variations in strength of sheet materials are not of major importance to users of resistance-welding processes as long as good fit-up of the workpieces is maintained. However, when poor fit-up conditions occur, and welding electrodes are used to deform the sheets to bring them into contact, some portion of available electrode force is used merely to overcome the spring action of the sheets. High-strength sheets have greater resistance to deformation and cause a greater reduction in effective clamping force. Unless electrode force is increased to compensate for this condition, pressure over the weld-nugget area may be reduced sufficiently to allow expulsion of weld metals.

Surface Condition: Condition of the material surfaces is particularly important in spot, seam, and projection-welding applications. Foreign substances on the surfaces, deposited during handling or storage or caused by reaction with the atmosphere or other agents, will increase contact resistance of the surfaces. High resistance at the interface between the sheet surface and electrode causes undesirable heating and dislocation. Excessive heating renders the water-cooled electrodes ineffective and not only results in marking of the sheet surface, but increases electrode pickup and decreases electrode life.

The need for clean faying surfaces is equally great. Since any dirt or oxide on the surfaces may not be uniformly distributed, variations in contact resistance may occur and

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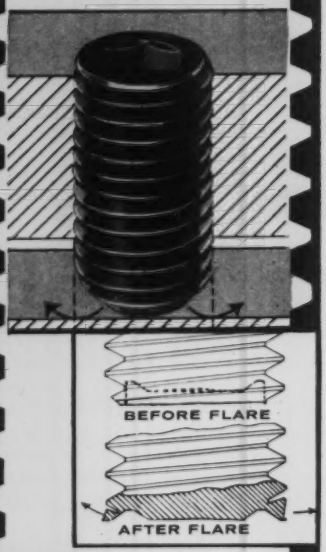
WILL NOT SHAKE LOOSE!



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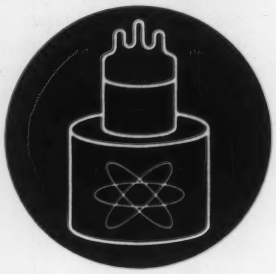

MB ELECTRONICS is the new name for MB Manufacturing Company.

This recent change in name is simply a long overdue reflection of the company's proper character. It is a reflection of the company's recognized capabilities in the field of electronic design, in the manufacture of audio range, high fidelity, high power amplifiers, in the programming of advanced vibration testing . . . and in the capabilities of the largest field service force to properly service electronically driven systems and aid on *any* problem of vibration testing.

As always, you can count on MB to keep you ahead in electronically powered systems of maximum performance capabilities, operating convenience, and test accuracy.

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1056 State Street, New Haven 11, Conn.
Pioneer and leader in the field of vibration

Now on tap . . .

20,000,000 watts of audio power

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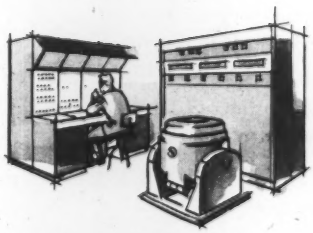
TWENTY million watts—that's the cumulative output available from MB power supplies now driving vibration test systems in the field.

The figure is more than a measure of the new importance of vibration testing. It's a measure of MB's technical advancement in the field of electronics for vibration, acoustics, and sonar.



And it's a measure of the company's unequalled background of experience in designing electronic power for dynamic forces . . . in producing *integrated* vibration testing systems including amplifiers of 100KW output and more, and exciters that utilize amplifier power more efficiently . . . in programming vibration tests to any required specification. This experience is available to you through MB's staff of vibration specialists and the largest force of field service technicians. Avail yourself of their expert recommendations on your vibration test problems.

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Circle 522 on Page 19

only McGILL® sealed *CAMROL*® cam followers give you . . .

effective sealing

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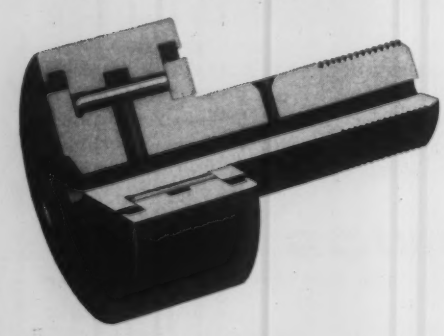

Effective sealing of the CAMROL cam follower against moisture, dirt, chips, etc. guarantees longer service life . . . reduces maintenance. This sealed construction retains lubricant and eliminates need for frequent relubrication, so often undesirable in cam action, guide support and track roller applications.

Special seals are built in at stud and flange ends. A black oxide finish on all exposed surfaces offers outside corrosion resistance. The channeled reservoir above the rollers in the outer raceway bore helps store reserve lubricant, sufficient in most cases for lifetime service. Relubrication is possible through convenient oil holes. The new SCF sealed CAMROL cam followers interchange with proven standard CAMROL cam followers. Standard stock with roll diameters up to 4" are available for both stud and shaft mounting.

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Circle 523 on Page 19

cause variations in amount of heat generated by the passage of welding current. Under these conditions weld-metal expulsion and nonuniform weld strength may be experienced.

PEI paper, Proceedings of the Porcelain Enamel Institute Forum, Vol. 20, pp. 13-25.

materials

Comprehensive Strength of Stainless-Steel Sandwiches

E. E. Mathauser and R. A. Pride, Langley Research Center

Results of testing stainless-steel sandwich specimens at temperatures from 80 to 1200 F. Specimens include resistance-welded 17-7 PH stainless-steel sandwiches with single-corrugated cores, Type 301 stainless-steel sandwiches with double-corrugated cores, and brazed 17-7 PH stainless-steel sandwiches with honeycomb cores. Experimental strengths are compared with predicted buckling and crippling strengths. Predicted crippling strengths and expected modes of failure are generally in good agreement with experimental results for corrugated-core sandwiches. High-temperature strengths predicted on the basis of correlation procedures show better agreement with experimental data than strengths obtained from a summation of the maximum strength of plate elements in the sandwiches. Specimens are fabricated with thick face sheets and relatively lightweight cores. Predicted strength of the honeycomb-core specimens is generally only in fair agreement with test results.

NASA Memorandum 6-2-59L, 50 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; paper 40 cents to members, 80 cents to nonmembers.

PEI—Porcelain Enamel Institute, Associations Bldg., 1145 19th St., Washington 6, D. C.

NASA—National Aeronautics and Space Agency, 1512 H St., N.W., Washington 25, D. C.

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Circle 524 on Page 19

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Heinze Blower-Heaters provide continuous operation on applications such as hot food vending machines; photographic dryers; plate and food warmers. Heater wattages are available in single ratings from 200 to 1200 watts. Heater can be thermostatically controlled through separate terminals. Coiled wire heating element is well insulated to protect outer walls.

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Circle 525 on Page 19

Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—Page 19

Time Overcurrent Relays

Inverse, very inverse, and extremely inverse designs of the Type CDG time overcurrent relay are featured in Bulletin 5-050 which covers both application and construction. They protect ac circuits and equipment against abnormal conditions. 16 pages. Federal Pacific Electric Co., 50 Paris St., Newark 1, N. J. C

Circle 681 on Page 19

Servovalves

Operating principles, design features, and performance characteristics of a new line of mechanical feedback servovalves are detailed in Catalog 310. These flow controls are usable in aircraft and missile systems as well as for industrial servo control applications. 8 pages. Moog Servocontrols, Inc., East Aurora, N. Y. N

Circle 682 on Page 19

Recorders & Controllers

Designed to indicate or record any variable measurable as a voltage or a resistance, electronic indicating recorders and indicating recorder-controllers are made in servo-balance potentiometer and bridge types. Full details are given in Bulletin 66. 4 pages. Thermo Electric Co., Saddle Brook, N. J. D

Circle 683 on Page 19

Cold Drawn Bar Steel

Jalcase 100 is a free-machining, stress stabilized, cold finished bar steel which is usable for needle bars, motor shafts, gears, hand tools, drill bushings, valve bodies, and hundreds of similar applications. Properties and design data on this material are given in Bulletin AD 226. 8 pages. Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, Pa. F

Circle 684 on Page 19

Bonded Mica Insulation

Revised Catalog M 59 on Micabond bonded mica insulation furnishes more complete information about properties, tolerances, and composition of various grades. Insulation is offered in fabricated parts, plates, sheets, segments, tapes, tubes, and V-rings. 16 pages. Continental-Diamond Fibre Corp., Newark, Del. C

Circle 685 on Page 19

Meehanite Metal

Alphabetical tabulations that show specific replacements of alloyed irons, steels, brass, bronze, and forgings, as well as type of Meehanite metal used in such applications are among contents of illustrated booklet, "Proof that Meehanite Bridges the Gap." 20 pages. Meehanite Metal Corp., 714 North Ave., New Rochelle, N. Y. D

Circle 686 on Page 19

Jig & Fixture Templates

Set of full scale tracing templates for toggle shoe clamps, hand knobs, spherical washers, studs, V-pads, T-slot nuts, jig feet, latch bolts, and other toolmakers components are found in booklet. Over 200 standard items are included. 8 pages. Northwestern Tools, Inc., 137 Hollier Ave., Dayton 3, Ohio. G

Circle 687 on Page 19

Insulating Resins

Scotchcast ready-to-use electrical insulating epoxy resins for electrical and electronic uses are subject of Bulletin E-PRSF. Application data for the several types offered are presented, along with properties and use information. 6 pages. Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn. J

Circle 688 on Page 19

Sub-Subminiature Switches

Two auxiliary actuators for 1SX1-T subsubminiature switches, described along with the switches in Data Sheet 148a, are made of corrosion resistant steel. They absorb side thrust from a cam or slide. 2 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 689 on Page 19

Polyphase Motors

Open dripproof or totally enclosed, fan cooled, and explosionproof types of polyphase motors are outlined in illustrated Bulletin SDA 105. Ratings from ½ to 30 hp are offered in frame sizes from 56 to 326U. 4 pages. Peerless Electric Co., Electric Motor Div., Warren, Ohio. G

Circle 690 on Page 19

Gage Pressure Guard

Protection for pressure-sensitive devices is offered by Gage Gard Jr. devices, offered in various cut-off pressures from 0 to 85 psi. Its specifications and general data are presented on Bulletin 547 G. 2 pages. Industrial Engineering Corp., Louisville 8, Ky. G

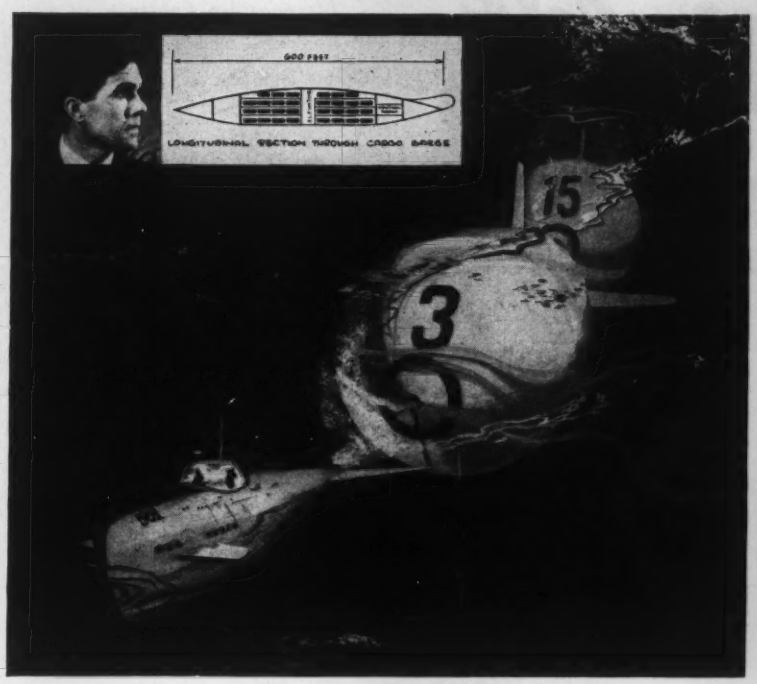
Circle 691 on Page 19

Pulse Generator

The 256-step precision pulse generator for calibration of multichannel pulse height analyzers with 2^n channels is subject of Form 3022-9. Suggested uses, operation, and performance data are included. 2 pages. Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio. F

Circle 692 on Page 19

No. 16 • Mars Outstanding Design Series



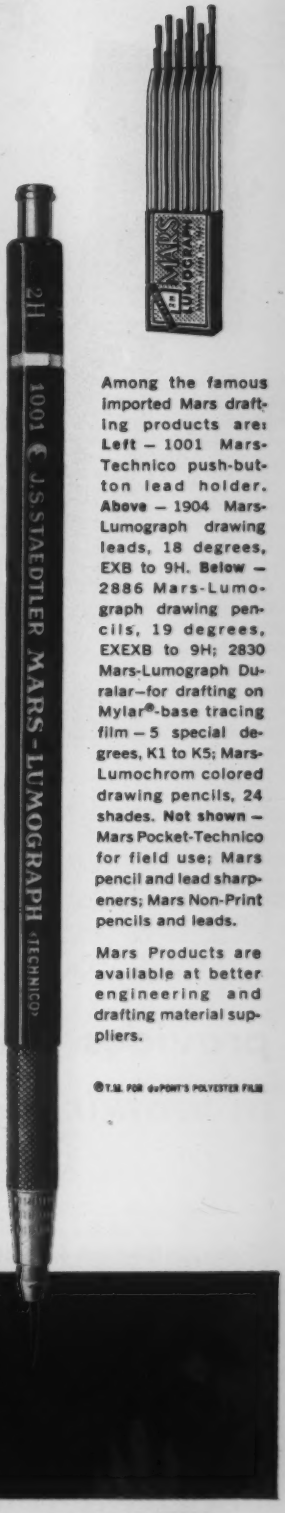
UNDERWATER CARGO – P. J. Carroll, M. E., of Dublin, Ireland, has developed this ingenious method of underseas shipping.

The tug, powered by nuclear reaction, tows a string of cargo vessels, taking advantage of ocean currents and sub-polar routes – free from delays due to weather or tides.

Power supply is adequate for years and tug can remain submerged indefinitely. It can transport cargo to and from many ports without surfacing, since based-in-port auxiliary submarine vessels uncouple the cargo carriers from tug and lead them into underwater pens. There cargo, stored in containers, is transferred by elevators and conveyors to trucks which are then sped by nuclear powered mono-rail to principal distribution points.

This nuclear-age concept of shipping is one more example of the contributions that today's designers are making. To help them translate their pace-setting ideas from concept to reality, they require the best of drafting tools.

In pencils that means MARS, long the standard of professionals.



Among the famous imported Mars drafting products are: **Left** – 1001 Mars-Technico push-button lead holder. **Above** – 1904 Mars-Lumograph drawing leads, 18 degrees, EXB to 9H. **Below** – 2886 Mars-Lumograph drawing pencils, 19 degrees, EXEXB to 9H; 2830 Mars-Lumograph Duralar—for drafting on Mylar®-base tracing film – 5 special degrees, K1 to K5; Mars-Lumochrom colored drawing pencils, 24 shades. **Not shown** – Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads.

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provides a 26.53% improvement in working efficiency!

(Even over the new 1960 Series)

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HELPFUL LITERATURE

Temperature Controls

Midget nonindicating temperature controllers with a −50 to 500° F range and miniature units with a −20 to 275° F range are covered in illustrated Catalog MC-182. Dimensions, electric ratings, and modifications are given. 4 pages. Fenwal Inc., Pleasant Street, Ashland, Mass. B

Circle 693 on Page 19

Terminal Board

Series MT miniature terminal board with 4 or 8 turret terminals is described and illustrated on data sheet. Voltage breakdown is 2500 v rms at sea level and 600 v rms at 60,000 ft. Mounting dimensions are given. 2 pages. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 694 on Page 19

Brakes & Clutches

Dimensional data, specifications, and performance curves for two electromagnetic brakes, an electromagnetic clutch, and an electromagnetic brake-clutch are content of Data Sheet 125. Minimum brake and clutch torques are 20 and 40 oz-in. 4 pages. Autotronics Inc., Florissant, Mo. H

Circle 695 on Page 19

Synchro Transmitter

Weighing less than ½ oz, the Size 8 synchro transmitter described in Data Sheet 801-T4 has a standard accuracy within 10 min. Dimensioned and schematic drawings are included, along with specifications. 2 pages. Daystrom, Inc., Daystrom Transicoil Div., Worcester, Pa. E

Circle 696 on Page 19

Magnetic Switch

Magnetically actuated and encapsulated, the Magnaswitch withstands high impact stresses and is impervious to environmental contaminants. No external physical contact is required. Described in catalog sheet, it handles linear or rotary applications. 1 page. Reed Research Inc., 1048 Potomac St. N.W., Washington 7, D. C. C

Circle 697 on Page 19

Thermostats

Nineteen major types of Stemco bimetal thermostats for use in appliances, apparatus, electronic, and avionic applications are covered in Bulletin 8400. Condensed technical data, operating ranges, ratings, and other information are given. 4 pages. Stevens Mfg. Co., Box 1007, Mansfield, Ohio. G

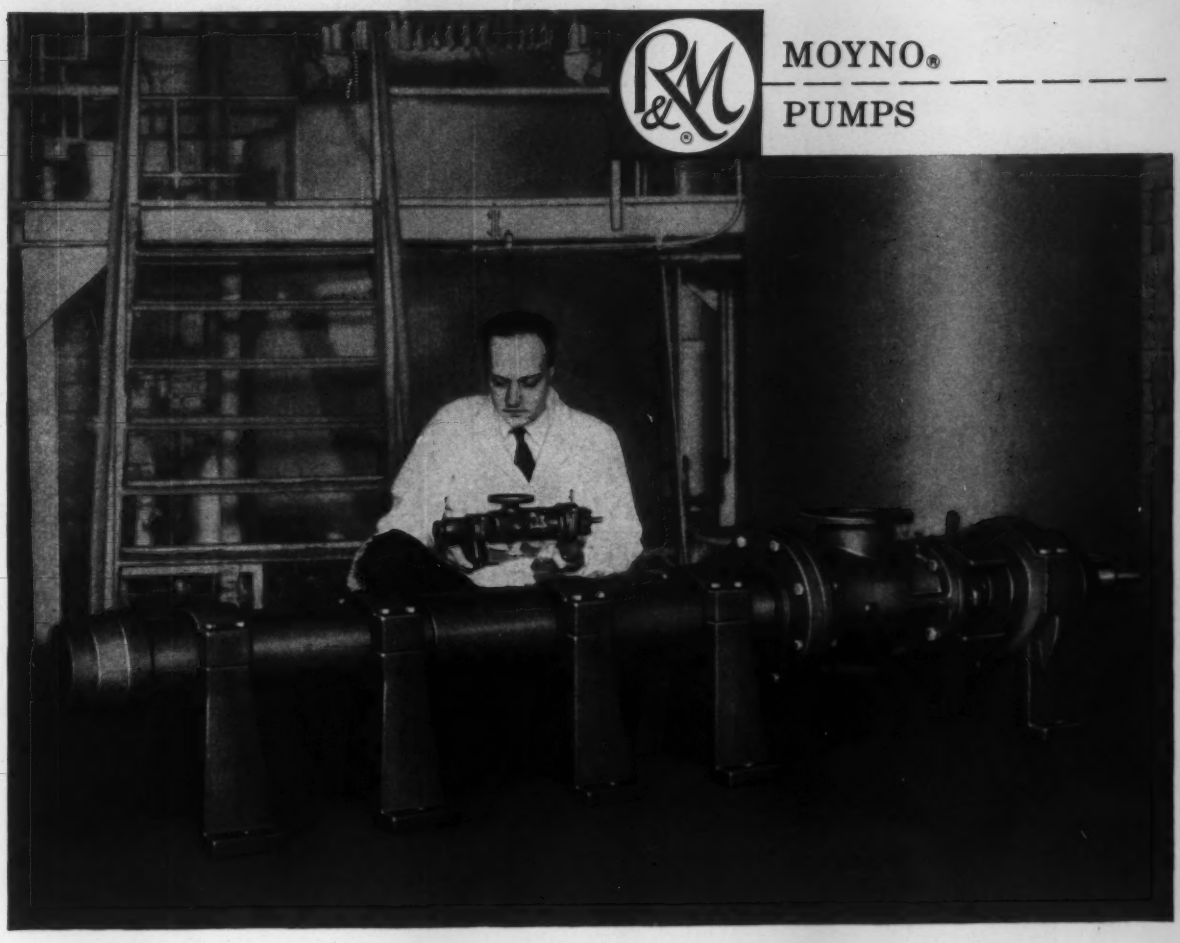
Circle 698 on Page 19

Glassed Iron Fittings

Glassed ductile iron fittings, subject of illustrated Bulletin 977, can safely be subjected to a sudden shock of 180° F. Physical and chemical characteristics are given, as are specifications of available fittings. Charts show strength. 2 pages. Pfaudler Co., Rochester 3, N. Y. N

Circle 699 on Page 19

Circle 527 on Page 19



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MOYNO pumps are available in nine sizes with capacities ranging from minimum metering flow to 500 gpm and pressures from zero to 1000 psi. Positive displacement delivers uniform discharge without pulsation, agitation or turbulence. Solutions ranging from thin watery slurry to extremely viscous paste, corrosives, abrasives and even solids in suspension are economically handled without excessive pump wear.

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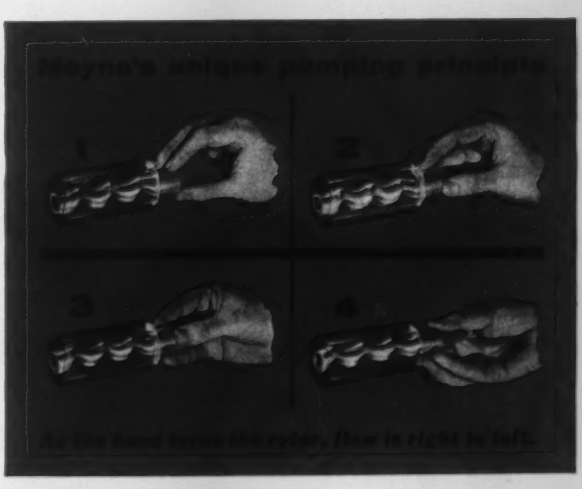

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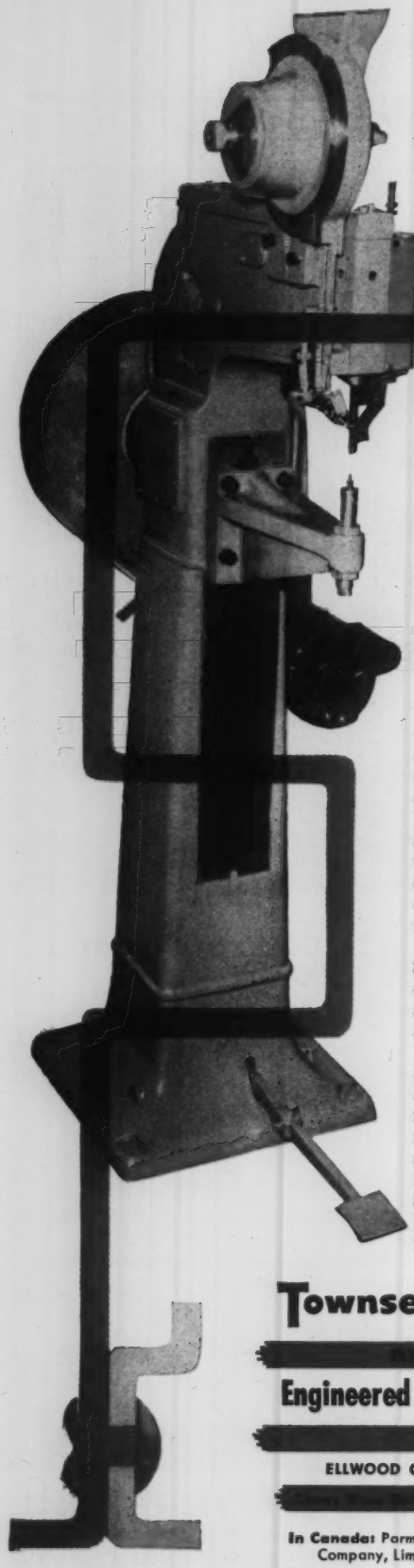
Circle 528 on Page 19



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The Townsend Tubular Rivet Setting machines are versatile and can be tooled for almost any size and shape of work. They are available in floor and table models.

Townsend tubular rivets are available in steel, brass, copper, aluminum and other special materials. Quick delivery is assured by manufacturing facilities and stocks maintained in strategic locations throughout the United States. For information write to Engineered Fasteners Division, P.O. Box 71-E, Ellwood City, Pa.

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HELPFUL LITERATURE

Footswitch

General purpose Clipper footswitch with extra wide treadle is offered with several types of circuits and momentary and maintained contacts. General data are given on catalog sheet. 1 page. Linemaster Switch Corp., Woodstock, Conn. B

Circle 700 on Page 19

Welding Fittings & Flanges

Nominal wall thickness for the various schedules of welding fittings, available in several steels and their dimensions are found in Technical Bulletin FDC-269. Also included are dimensions for forged steel flanges. Nominal pipe size is 18 in. 6 pages. Babcock & Wilcox Co., Tubular Products Div., Milwaukee 46, Wis. K

Circle 701 on Page 19

Sealed Relays

Up-to-date information on hermetically sealed microminiature, subminiature, miniature, and high speed relays for military and general purpose uses is found in illustrated Bulletin GEA-6628. Circuit diagrams, coil data, and specifications are included. 24 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 702 on Page 19

Indicators & Controllers

Electronic self-balancing indicators and indicating controllers which indicate any process variable convertible to an electrical quantity are described and illustrated in Bulletin 65. Instruments can have two or three-position control, or up to six alarm contacts. 4 pages. Thermo Electric Co., Saddle Brook, N. J. D

Circle 703 on Page 19

Heat-Humidity Chambers

Series of temperature and humidity chambers ranging from a 2-cu ft portable unit up to a 10-cu ft production testing model is subject of Folder 102. Specifications of available models are given. 4 pages. Harris Refrigeration Co., 308 River St., Cambridge 39, Mass. B

Circle 704 on Page 19

Silicone Potting Gel

Clear dielectric silicone potting gel cures in place to form a resilient, protective mass that retains dielectric properties and moisture resistance over temperature span of −60 to 200° C. Brochure 10-505 provides property tables and shows that gel exerts no damaging stress on delicate parts during or after cure. 4 pages. Dow Corning Corp., Midland, Mich. H

Circle 705 on Page 19

Polyurethane Rubber

Available in cast form for a wide range of industrial applications, Neothane polyurethane rubber is descriptively covered in Bulletin S-5125. In pure gum form, Neothane is harder than most conventional rubber compounds and has from two to four times the strength. 8 pages. Goodyear Tire & Rubber Co., Akron 16, Ohio. F

Circle 706 on Page 19

PHOTO BY KARSH OF OTTAWA

"Supplier reliability is a must to sound product development"

—R. W. SWANK, Research and Development, Smith-Erie Div., A. O. Smith Corp.

"We count Sharon Steel as one of our most dependable suppliers, and this is extremely important to a development engineer," says R. W. Swank, Manager of Research and Development of service station pumps in the Smith-Erie Division of A. O. Smith Corp.

Shown here with P. R. Fishburn, Manager of Manufacturing, Swank points out "If we can design with the knowledge that we need not be concerned about material analysis variation, our jobs are made that much easier. We've found we can expect this kind of supplier reliability from the *Sharon Steel Corporation, Sharon, Pa.*"

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Circle 530 on Page 19

Circle 531 on Page 19

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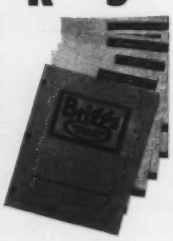

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Circle 532 on Page 19

HELPFUL LITERATURE

Glass Fiber Plastics

Catalog No. 2 lists materials for fibrous glass reinforced plastics. Available sizes, grades, and prices are shown under each material along with thumbnail descriptions of properties and recommended applications. 16 pages. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich. H

Circle 707 on Page 19

Railroad Fasteners

Series of two-sided and blind threaded fasteners and rivets for use in the railroad industry is described and illustrated in Bulletin 8-471. General specifications and typical uses are given. Application tools are briefly described. 4 pages. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich. H

Circle 708 on Page 19

Dry Fluid Drive

Practical problems solved by Flexidyne dry fluid drives are pointed up in Bulletin A640B. Selection data, thermal capacities, V-belt drive recommendations, and other information are presented. Expanded line of drives comprises fractional to 1000-hp units in ten stock couplings and eight stock drives. 24 pages. Dodge Mfg. Corp., Mishawaka, Ind. J

Circle 709 on Page 19

Equipment Connectors

Complete information on Joy equipment control connectors designed for applications up to 600 v is provided in Bulletin B72. Constructed of neoprene, connectors are available in oval, round, or dual round styles with from 2 to 12 poles. 12 pages. Joy Mfg. Co., Electrical Products Div., 1201 Macklind Ave., St. Louis 10, Mo. I

Circle 710 on Page 19

Sheave Corrosion

"Licking Fretting Corrosion in Variable-Speed Sheaves" is title of Bulletin 7102 which discusses several ways to control wear by fretting corrosion. 6 pages. T. B. Wood's Sons Co., Chambersburg, Pa. E

Circle 711 on Page 19

Data on Solvents

Comprehensive data on 14 glycol-ether solvents contained in Brochure F-4765E cover physical properties, chemical derivatives, end-use possibilities, storage and handling, physiological properties, specification limits, and test methods. Solvents are effective on resins, oils, waxes, fats, dyestuffs, and other organics. 40 pages. Union Carbide Chemicals Co., 30 E. 42nd St., New York 17, N. Y. C

Circle 712 on Page 19

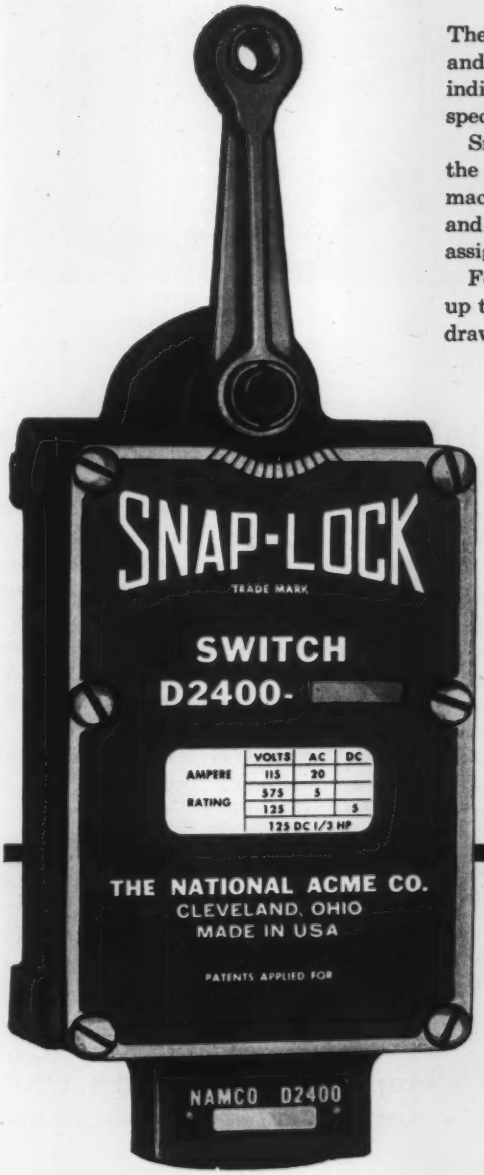
Gearmotors

Design and construction features of integral and all-motor type gearmotors available from 1/4 to 100 hp are furnished in Bulletin 51B9172. Right angle, as well as special designs are included. 8 pages. Allis-Chalmers Mfg. Co., Milwaukee 1, Wis. K

Circle 713 on Page 19

SNAP-LOCK Limit Switches

Actuate Two Circuits Simultaneously ...Without Special Linkage



The D-2400 series Snap-Lock Limit Switches with two normally open and two normally closed contacts permit making or breaking two individual circuits simultaneously. Mounting problems are simplified, special linkages eliminated and costs kept to a minimum.

Snap-Lock Limit Switches were originated by National Acme to meet the severe mechanical and electrical conditions imposed by all types of machine tools. The outstanding simplicity and ruggedness of these water and oil tight switches make them adaptable to the toughest heavy-duty assignments.

Four basic models with a wide variety of actuating levers will handle up to 5 amps, 600 volts, AC. For complete details, parts list, and scale drawings, write for Bulletin EM-5824.

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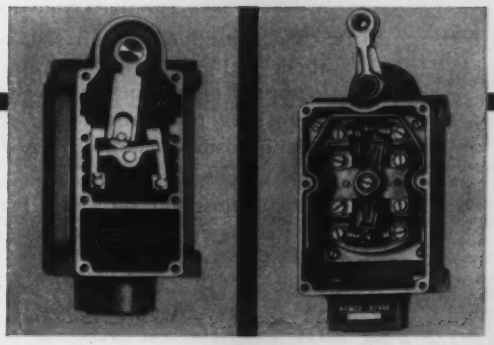
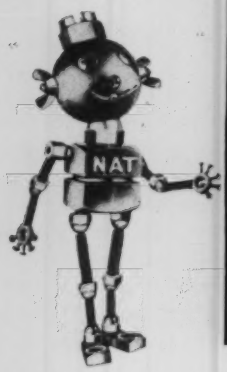


All Snap-Lock switches have separate enclosures within a single housing for the mechanical and electrical sides. Ample wiring space is provided and maintenance greatly simplified.

Circle 533 on Page 19

NAT'S
quick facts
about
Fasteners...



Welding Fasteners...

the little things that make a big difference

Welding Fasteners put threads into the most unlikely places, and make light of the weightiest assembly problems.

Where hands and wrenches can't get in, for instance, or where material dimensions or contours make it next to impossible to use regular fastening methods, Weld Nuts or Weld Screws neatly side-step the difficulties . . . and make assembly simple, fast and foolproof.

We could go on and tell you more about Welding Fastener advantages . . . in improving product design and quality, increasing production efficiency, and cutting costs . . . and we'll be very glad to, if you like.

Right now, though, we'd just like to say that when you need certain standard Weld Nuts or Weld Screws, and you want to be sure they're designed right and made right . . . that's where we come in. We *know* Welding Fasteners, and we *stock* many of the most commonly used.*

We might just mention, too, that we happen to be particularly adept at developing Special Fasteners for welding. They can often be designed to do a better job and save money for you. Ask us about your applications.

*Standard types and sizes are illustrated and listed in National's booklet on Welding Fasteners. Write for your copy.

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DC Circuit Breakers

Type FB circuit breakers are high-speed, heavy-duty units available in ratings from 1200 through 12,000 amp continuous current, at 1000 v dc. Bulletin 4601-1A covers design, performance, applications, ratings, dimensions and weights. 4 pages. I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa. E

Circle 714 on Page 19

Pumps

High measure of pump standardization achieved with the Veriflow vertical single-stage pump is brought out in fact folder. Pump covers the range of 1, 1½, 2, 3, and 4 in. pumps for petroleum, chemical, and petrochemical industries. 4 pages. United Centrifugal Pumps, 580 Second St., Oakland, Calif. M

Circle 715 on Page 19

Corrosion Chart

Comparative corrosion resistance of zirconium, titanium, tantalum, Hastelloy C, and stainless 316 tubing to 43 common reagents is tabulated on 22 x 17-in. wall chart. Materials are shown with ratings from "excellent" to "not recommended" for various concentrations and temperatures. Damascus Tube Co., Greenville, Pa. G

Circle 716 on Page 19

AC Generators

Nine specification sheets covering 18 different models of standard alternating-current generators ranging from 1 to 250 kw, 1.5 to 312 kva are available. Sheets provide dimensional drawings and generator characteristics. Kato Engineering Co., Mankato, Minn. J

Circle 717 on Page 19

Packaged Pipelines

Folder pictorially depicts the handling of a purchase order from customer specification to trenchsite delivery of Lite-Wall packaged pipelines. Specs are listed for diameters from 3½ to 14 in. 6 pages. U. S. Industries, Inc., Southern Pipe Div., Box C, Azusa, Calif. L

Circle 718 on Page 19

Phosphor Bronze Rod

Phosphor bronze rod is particularly adapted to applications requiring corrosion resistance, strength, electrical conductivity, antifriction properties, low temperature performance, or nonmagnetic qualities. Descriptive brochure includes physical mechanical, and fabricating properties. 10 pages. Bridgeport Brass Co., 30 Grand St., Bridgeport, Conn. B

Circle 719 on Page 19

Magnetic Tape Products

Five bulletins contained in folder jacket describe line of miniature, lightweight amplifiers and power supply for magnetic tape recording. Type 3-135 power supply furnishes plate and filament voltage for 14 record amplifiers. 2 pages each. Consolidated Electrodynamics Corp., Data-Tape Div., 360 Sierra Madre Villa, Pasadena, Calif. L

Circle 720 on Page 19

BUILD YOUR BUSINESS ALONG THESE LINES

with BIJUR Automatic Lubrication

By incorporating the Bijur System into your designs, you can offer substantial operating economies which progressive users now demand. For example, in the metalworking field 75% of machinery users prefer "built-in" automatic lubrication on the machines they buy.

Costly hand lubrication is eliminated.

Production time is saved because machines are oiled while in operation.

Bijur Automatic Lubrication is the best friend a bearing ever had. Every bearing is automatically fed a metered shot of oil at predetermined intervals.

Inaccessible bearings that require regular lubrication are never neglected.

There can be no problem of work spoilage or bearing headaches caused by over lubrication.

Leading machine builders have standardized on Bijur for a quarter of a century. Bijur puts the accent on engineering design — to satisfy the specific requirements of your machines.

Our engineers can show you how to build increased dependability into your machines, whether they are in production or still on the board.

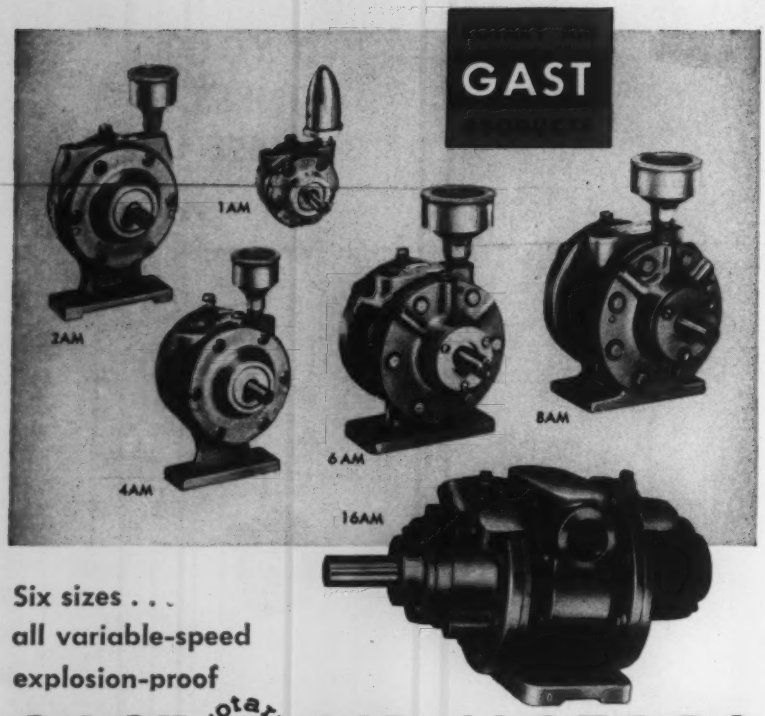
BIJUR AUTOMATIC LUBRICATORS—STANDARD EQUIPMENT IN MANY INDUSTRIES
Machine Tools • Business Machines • Printing Machinery • Textile Machinery • Food Product Machines • Bottling Machines • Packaging Machines • Sheet Metal Machines • Plastic Fabricating Machinery • Glass Products Machinery • Wood-Working Machinery • Industrial Sewing Machines • Special Process Equipment

Write for literature and engineering data.

BIJUR LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

3370 -A

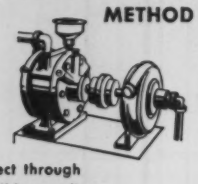
Circle 535 on Page 19



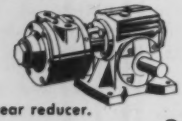
Six sizes . . .
all variable-speed
explosion-proof

GAST rotary vane AIR MOTORS

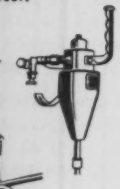
CHOOSE YOUR DRIVE METHOD



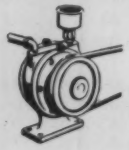
Direct through flexible coupling.



Use gear reducer.



Flange mounted – vertical operation.



Driving pulley.

Need a compact, low-cost motor for original equipment or plant use applications? *Air may be your answer . . .* using one of these efficient Gast rotary-vane Air Motors. Look at the special advantages they offer you:

1. They're explosion-proof — no sparks, no danger!
2. Low initial cost compared to other motors.
3. Speed variable with simple valve control.
4. Can't burn out if overloaded or stalled.
5. Reversible rotation optional on some models.
6. Rotor vanes take up their own wear.
7. Quickly attached to plant air lines.
8. Amazingly light, compact for h.p. delivered.
9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

Gast Air Motors are supplied as original equipment on pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, spooling machines and a host of other products. Used in explosive atmospheres and in "hot" locations to 250° F.

Model No.	1AM	2AM	4AM	6AM	8AM	16AM
H.P. at 90 P.S.I., 2000 RPM	0.13	0.57	1.1	2.0	4.0	7.0
Weight, lbs.	1½	5½	8	17	25	65

For complete performance data, write for Air Motor Bulletins. Specify models that interest you.

GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

Circle 536 on Page 19

HELPFUL LITERATURE

Spring Clutches

Five standard lines of spring clutches covered in catalog are designed for use in machinery, equipment and instruments utilizing drive up to 5 hp. They are offered in bore sizes from ⅛ to 1 in. and torques up to 1250 lb-in. 30 pages. Curtiss-Wright Corp., Marquette Div., 1145 Galewood Dr., Cleveland 10, Ohio. G

Circle 721 on Page 19

Motor Starters

Bulletin GEA-6860 tells when and where to use, and how to select G-E reduced-voltage motor-starting equipment. Units are used for starting squirrel-cage motors that drive motor-generators, pumps, saws, compressors, air conditioners, machine tools, and other equipment. 8 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 722 on Page 19

Air Cylinder Accessories

Form 70-VR introduces a bleeder valve and accessory pin for use on Allenair cylinders of 1½, 2, 2½, 3, and 4-in. bore sizes. Former bleeds air from another piece of equipment as rod reaches end of its stroke. 2 pages. Allenair Corp., 255 E. 2nd St., Mineola, N. Y. D

Circle 723 on Page 19

Vibration Interferometer

The 1333 Vibration Interferometer is designed for precise checking and calibration of accelerometers. Bulletin 204-59 describes applications, features and specifications of instrument which has a 450 to 10,000 cycle frequency range. 2 pages. Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill. I

Circle 724 on Page 19

Flexible Couplings

Data on the new Series X Dihedral coupling which permits shaft misalignment up to 5 degrees per set of gear teeth are presented in Bulletin 62. Diagrams of the coupling as well as tables of sizes and bores are included. 2 pages. John Waldron Corp., Box 791, New Brunswick, N. J. D

Circle 725 on Page 19

Filter Media

Selection chart guides the choice of the proper engineering materials and filter media for specific types of corrosive conditions. Booklet PUR-66D lists filter media for varying concentrations of more than 125 corrosive agents. Metallic, plastic, and other types are covered. 12 pages. Purolator Products, Inc., Rahway, N. J. D

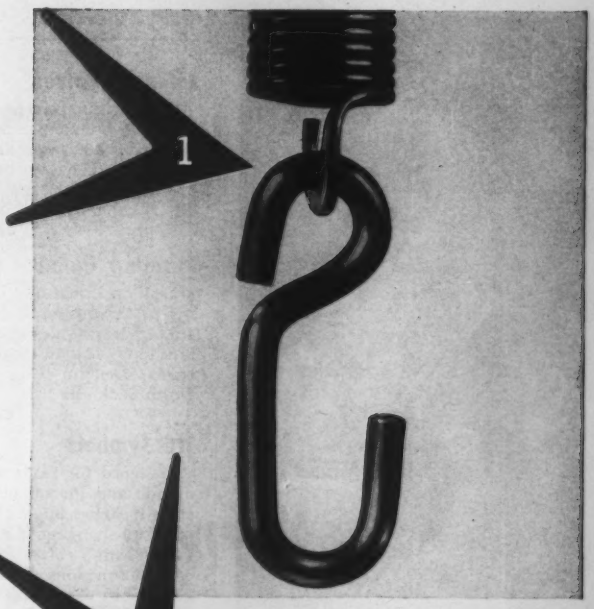
Circle 726 on Page 19

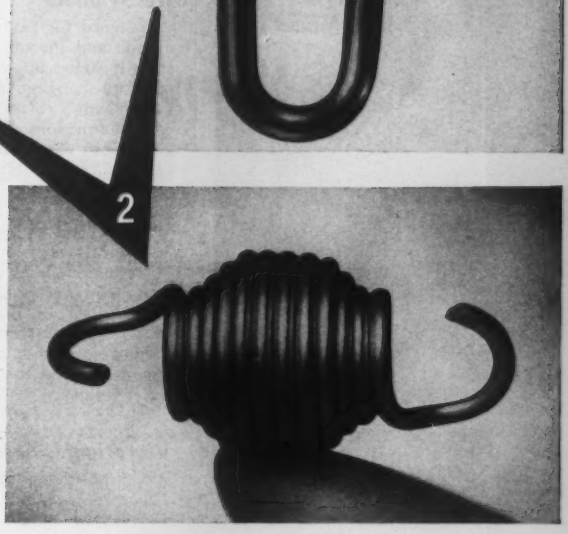
Shaped Tubing

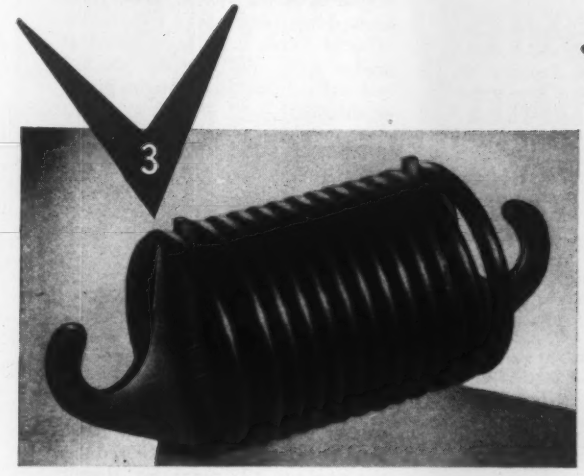
Shaped tubing in square, rectangle, elliptical oval, and a variety of other cross sections is subject of Data Memorandum 17. Shaped tubing is available in several analyses which include stainless, carbon, and alloy steels; nickel and nickel alloys; glass-sealing alloys; titanium; and beryllium copper. Properties and applications are covered. 4 pages. Superior Tube Co., 1578 Germantown Ave., Norristown, Pa. E

Circle 727 on Page 19

Why it pays to look at the end in the beginning







1. In this pick-arm spring for a textile machine, natural frequency vibration plus rigid end restraint caused early failure. By redesigning spring and adding swivel hook to end assembly, failure was avoided and cost reduced as well.

2. Fatigue failure caused by bending stresses occurs where end hooks join working coils. In this method of reducing the combined stress, two coils at each end are wound with a reduced diameter.

3. Another method for reducing stress concentration where end hooks join coils is to thread a flat stamping into end coils.

Here are a few examples of why it pays to call on the springmaker early in your design problems. End-hook failure of extension springs is a common occurrence that experience can help avoid. Check your specifications for performance and production economy by consulting an A.S.C. spring engineer. Write for bulletin "How to Solve Your Spring Design Problems."

5901

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
F. N. Manross and Sons Division, Bristol, Conn.
San Francisco Sales Office, Saratoga, Calif.
Seaboard Pacific Division, Gardena, Calif.
Cleveland Sales Office, Cleveland, Ohio
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

"BUILDING BLOCKS" CUT STOCKING COSTS

Reduce costly inventories—gain valuable storage space. Take advantage of General Electric's new "building-block" d-c contactors and relays and stock only a few standard parts. Desired devices can then be quickly and easily assembled when needed. Get complete details by following reader service instructions below. General Electric Company, Roanoke, Va.

784-20

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 538 on Page 19

HELPFUL LITERATURE

Solenoid Valves

Bulletin supplement Form V5069 describes two-way packless solenoid valves for steam, hot gases, and light liquids up to 350° F. They are made in ⅜, ½, and ¾-in. sizes. 2 pages. Automatic Switch Co., Florham Park, N. J. D

Circle 728 on Page 19

Rotating Unions

Deublin rotating unions for water, steam, air, hydraulic, vacuum, and coolant service are described and specified in brochure. Sixteen models are covered. 20 pages. Deublin Co., 1919 Stanley St., Northbrook, Ill. I

Circle 729 on Page 19

JIC Symbols

Designed for ready reference, "JIC Hydraulic and Pneumatic Symbol" reference chart measures 8½ x 11 in. and is punched for wall hanging. Cross references refer to company's valves for air and hydraulic control functions. 2 pages. Republic Mfg. Co., 15655 Brookpark Rd., Cleveland 35, Ohio. G

Circle 730 on Page 19

Dial Indicators

The Miracle Movement which extends operating life and improves resistance to shock and wear of line of dial indicators is described in Bulletin A-614. Various types of gage indicators are available with graduations ranging as fine as 0.00005 in. 4 pages. Federal Products Corp., 1144 Eddv St., Providence 1, R. I. B

Circle 731 on Page 19

Vibration Isolators

Charts, design details, and application information on Barry shock and vibration isolators for mounting all types of industrial equipment and machines are contained in illustrated Bulletin 59-04. These units isolate vibration, attenuate noise, and reduce shock. Engineering and application procedures are given. 4 pages. Barry Controls Inc., 700 Pleasant St., Watertown 72, Mass. B

Circle 732 on Page 19

Metal Packing

Comprehensive data for the correct selection, application, and installation of metal packings for pumps, engines, and compressors are included in Bulletin AD-166. Design information is given on free-floating, metal rod, metal scraper, and metallic or nonfloating packings and on piston rings. Testing and service facilities are outlined. 24 pages. Garlock Packing Co., 438 Main St., Palmyra, N. Y. N

Circle 733 on Page 19

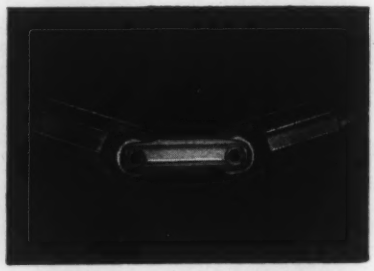
Electric Power Supply

Designed to develop any voltages from 26 to 2000 v dc at 100 w output from an input of 28 v dc, the Model 851H transistorized power supply meets Military Specs. Full details are given in Bulletin S-2-19. 2 pages. Arnold Magnetics Corp., 4613 W. Jefferson Blvd., Los Angeles 16, Calif. L

Circle 734 on Page 19

How Curtis helped a design engineer "BEAT THE HEAT"

This single universal joint in a ribbon-stripping machine was operated at a 34° angle. The joint heated up, wear was excessive. (Curtis Joints have been tested at angles up to 37°, but we do not ordinarily recommend angles greater than 30°.)



Curtis engineers recommended a *double* Curtis joint, which reduced the angle to 17° per joint. Result: no overheating, improved efficiency, longer life.

You can depend on Curtis engineering in any problem of angular power transmission. And you can depend on

CURTIS UNIVERSAL JOINTS

because our catalog torque and load ratings are substantiated by constant tests under production conditions.

14 SIZES ALWAYS IN STOCK —
⅜" to 4" O.D. (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK CURTIS

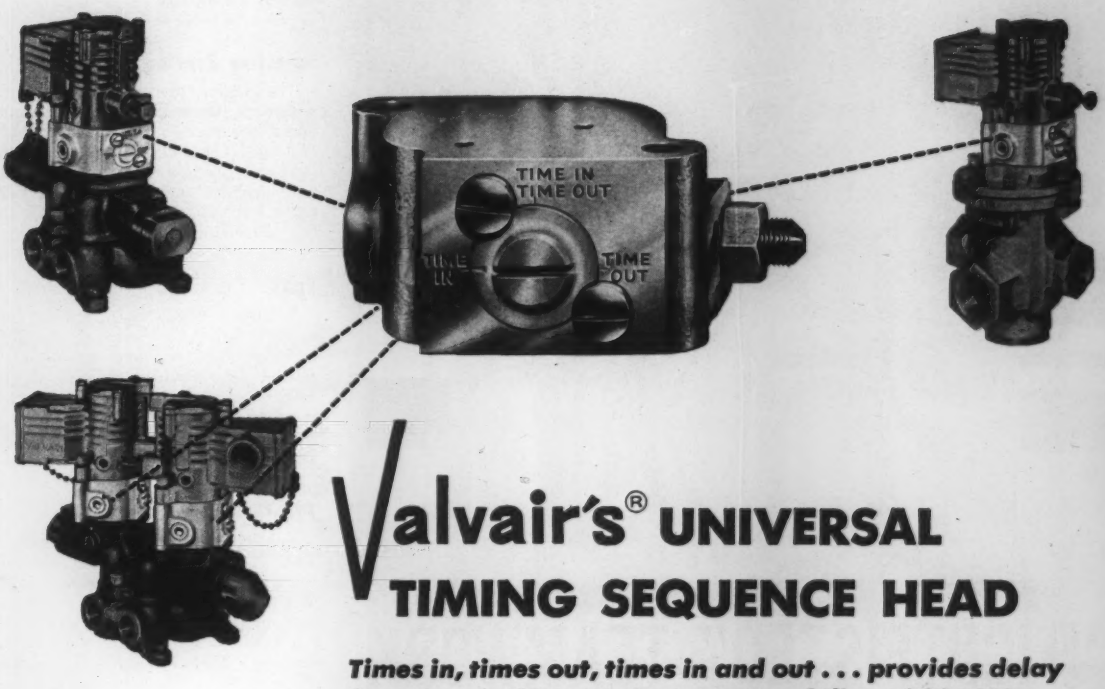
UNIVERSAL JOINT CO., INC.

5 Birnie Avenue, Springfield, Mass.

As near to you as your telephone

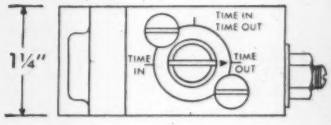
EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 539 on Page 19



Valvair's® UNIVERSAL TIMING SEQUENCE HEAD

Times in, times out, times in and out . . . provides delay from 0 up to 30 seconds . . . repeatability within 2% . . . changes function without disassembly . . . for use with any Valvair Speed King or Inline Valve



For accurate control, to simplify circuits, to eliminate timers and relays, to lower control component installation and maintenance costs, use Valvair's universal timing sequence head. This unit is supplied in two types; one for direct mounting between the pilot and valve body; one for direct mounting on the valve body, with remote pilot control.

Function can be changed in seconds, *without disassembly* and with line pressure on the valve. Just loosen the lock screws slightly, turn the indicating barrel to the desired function mark, then tighten the lock screws.

A port is provided for installation of accessory reservoir capacity . . . delay can be extended up to several minutes. And, the Valvair name on this unit is your assurance of sound design, quality construction, micro-accurate performance and multi-million cycle dependability!

Find out how Valvair's sequence head can provide the results you want, at a cost saving you'll like, on the new equipment you're designing or on existing machines you're up-grading. Yes, this sequence head can be used on your present SPEED KING and INLINE valves, too. Ask your Valvair or Bellows Field Engineer for recommendations . . . they're located in over 125 major industrial cities.

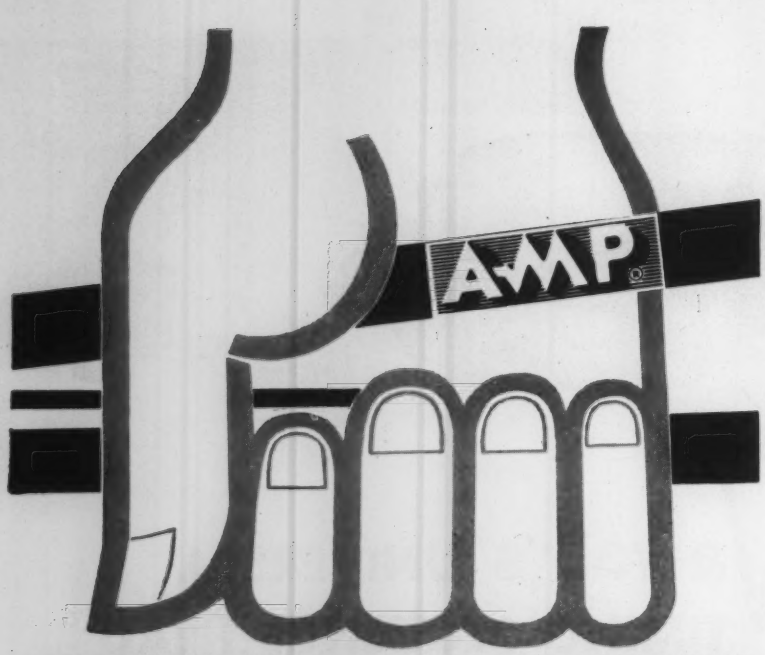
For more information, write for Bulletin E-1A. Address Dept. MD959, Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio.

Valvair AKRON 11, OHIO

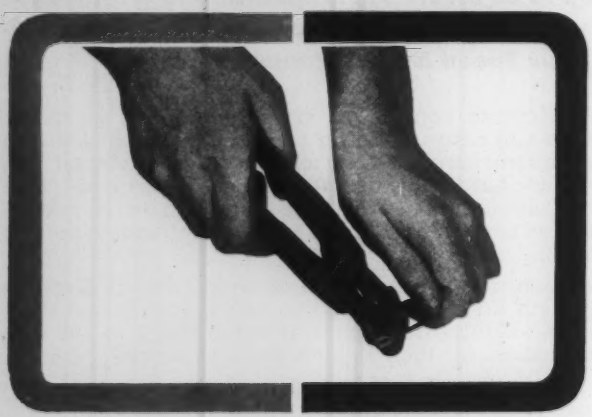
Other INDUSTRIAL DIVISIONS of IBEC: The Sinclair-Collins Valve Co. The Bellows Co., Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio.

8079

Circle 540 on Page 19



"TIGHTFISTED" TEAMWORK



Each A-MP tool-and-terminal team is designed to be inflexibly "tightfisted" with your money . . . designed to reduce your total circuit termination costs. You can *really* put the pressure on circuit termination expenses with these A-MP teams because AMP has cleaned out all the profit eating clutter and mess found in other methods.

This AMP method is tightfisted in another way. The A-MP tool won't "let go" until the precise crimp is made to create unquestioned reliability. Your choice of precision hand tooling or high speed automatic tooling.

Tightfisted for economy, tightfisted for reliability—the AMP method gives you these along with many other plus features including coded quality control, vibration and corrosion resistance and pre-insulation.

Write today for our Cost Saving Brochure.

AMP INCORPORATED

General Offices: Harrisburg, Pennsylvania

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

Selective Plating

The Dalic process for electroplating selected areas without use of immersion tanks is explained in illustrated bulletin. Plating is suitable for repair as well as production applications. Many common and precious metals can be applied. 4 pages. Sifco Metachemical, Inc., 935 E. 63rd St., Cleveland 3, Ohio. F

Circle 735 on Page 19

Epoxy Coatings

What to expect when various coal tar epoxy coatings are exposed to different corrosive solutions and environments is related in technical Bulletin R-20. Results of tests involving salts, acids, caustics, weathering, and other hazards are cited. 8 pages. Amercoat Corp., 4809 Firestone Blvd., South Gate, Calif. L

Circle 736 on Page 19

Plastic Shapes

Kel-F fluorocarbon plastic is now available in molding sheet, molding and extruded rod and tube, as well as compression and transfer molded custom parts. Full information on this material and its available forms are given in illustrated bulletin. Fluoro-Plastics, Inc., 36th & Filbert Streets, Philadelphia 1, Pa. E

Circle 737 on Page 19

Thread-Sealing Fittings

Design and application of Tru-Seal pipe thread fittings for use on new or existing piping are discussed in bulletin. Fittings have an integral Teflon seal in a steel back-up nut, and they can be reused many times. They are available for ⅛ to 2½-in. pipe and tubing applications. 4 pages. Flick-Reedy Corp., Tru-Seal Div., 7N015 York Rd., Bensenville, Ill. J

Circle 738 on Page 19

Reversible Timing Motor

The 26100 Series reversible 60-cycle ac timing motor described in Bulletin MO 807 operates on 115 v. Specifications, dimensions, and design features are pointed out. 2 pages. A. W. Haydon Co., Waterbury, Conn. B

Circle 739 on Page 19

Air-Powered Equipment

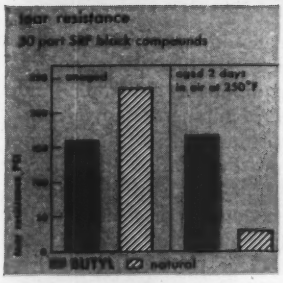
"A Panorama of Production Ideas" is title of illustrated brochure which gives examples of the ways in which air motors and other Controlled Air Power work units can cut costs, increase productivity, improve quality, reduce scrap, and prolong tool life. Services available from company as listed. 16 pages. Request on company letterhead from Bellows Co., Akron 9, Ohio. F

Nonferrous Bars

Sizes, pounds per foot, and alloy specifications for brass, bronze, and nickel-silver rectangular and square bars are found in folder. Alloys covered include free-cutting, forging, cartridge, and Naval brasses, Muntz metal, manganese bronzes, and nickel-silver, 8 pages. Request on company letterhead from Titan Metal Mfg. Co., Bellefonte, Pa. G

ENJAY BUTYL

RUBBER FOR RESISTANCE TO TEAR AND ABRASION



Enjay Butyl offers the highest aged tear strength of any rubber. Even after long exposure to heat, oxygen and ozone, Butyl retains nearly all its original tear and flex resistance...keeps its stretch without tearing. And Butyl's inherent toughness offers rugged resistance to abrasive wear. Butyl is the preferred rubber and proven superior in such applications as conveyor belts, hoses, heavy-duty off-the-road truck tires, and other mechanical goods.

Butyl also offers...outstanding resistance to chemicals, weathering, sunlight, heat, and electricity...superior damping qualities...unmatched electrical properties and impermeability to gases and moisture.

Find out how this versatile rubber can improve your product. Call or write the Enjay Company, today!

ENJAY BUTYL

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC., *15 West 51st Street, New York 19, N.Y.*

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

Circle 542 on Page 19

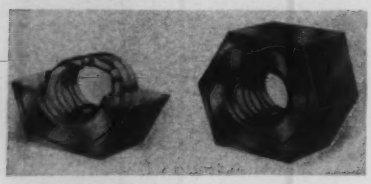
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Aluminum Lock Nut

resists temperatures to 550 F

Tru-Lok self-locking aluminum lock nut incorporates a high-strength, spring-temper, stainless-steel wire form in an aluminum body. Nut meets all performance requirements of MIL-C-25027 for 550 F operation, as well as 250 F. Shape of middle coil winding produces ac-



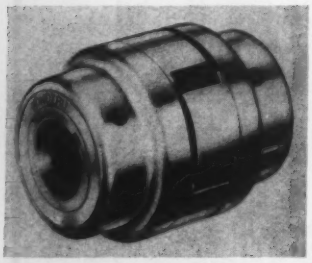
curately controlled pressure, exerted uniformly and radially, for unvarying torque and locking friction that assures vibrationproof, constant position. Wire-thread design contributes extensive reusability, negligible wear, no galling, seizure, or deformation of mating threads, and high strength-to-weight ratio. Range of sizes in both coarse and fine-series thread is available. **Waltham Precision Instrument Co.**, 221 Crescent St., Waltham 54, Mass. B

Circle 740 on Page 19

Flexible Couplings

transmit up to 10 hp at 1800 rpm

Aluminum Bondtru flexible insulated couplings for light-duty applications are available in six sizes with 20 standard bore sizes from ¼ to 1½ in. They are furnished with keyways and setscrews, and transmit up to 10 hp at 1800 rpm. Couplings have only three parts—two aluminum flanges with projecting segments that engage each other through a nonmetallic insert which carries load in compression. Nonconducting insert also eliminates



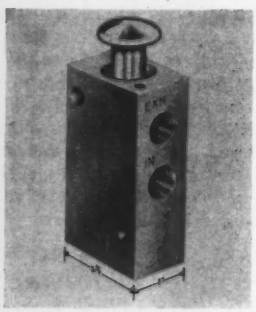
static and dynamic electricity, and absorbs shock and torsional vibration. Units weigh from about 5 oz to 2 lb. They are self-aligning, and automatically compensate for endplay, lateral, and angular misalignment. No lubrication is required. **Charles Bond Co.**, 617 Arch St., Philadelphia 6, Pa. E

Circle 741 on Page 19

Directional-Control Valve

subminiature unit has long life

Built especially for limited mounting space, subminiature, directional-control valve is only 1 in. thick and 1½ in. wide. Change of O-rings after long service provides long valve life. Valve is suitable for controlling small cylinders, and for operating diaphragms and pilot cylinders. It is available in three and four-way versions milled from solid aluminum bar stock, and is furnished tapped for ¼ or ⅛-in. pipe connections. Valve is rated for 0



to 125 psi for air, oil, water, or high-vacuum service. Six actions are available: Palm operated; lever operated; ball-cam actuated; pilot operated, spring returned; double-pilot operated; pilot-operated, bucking-cylinder returned. **Hunt Valve Co.**, Salem, Ohio. G

Circle 742 on Page 19

Perforated Steel

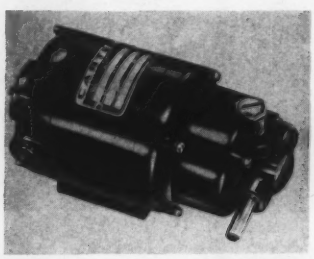
is available in 12 new patterns

Line of stock perforated patterns now contains 12 new decorative designs. They are available in 36 x 120-in. sheets of 22 and 24-gage steel. Several designs are also furnished in 20-gage steel. **Harrington & King Perforating Co. Inc.**, 5670 Fillmore St., Chicago 44, Ill. I

Circle 743 on Page 19

Gear Motors

ten sizes have outputs from 10 to 750 rpm



Classic gear motors provide power for business machines, computers, medical equipment, electronic and geophysical equipment, movie cameras, teleprinters, scientific instruments, and duplicating machines. Ten standard single and double-worm-reduction models are available, with shaft outputs from 10 to 750 rpm. Gear train employs first worm cut directly on motor shaft for high efficiency. Shaft worm and secondary worm are case-hardened

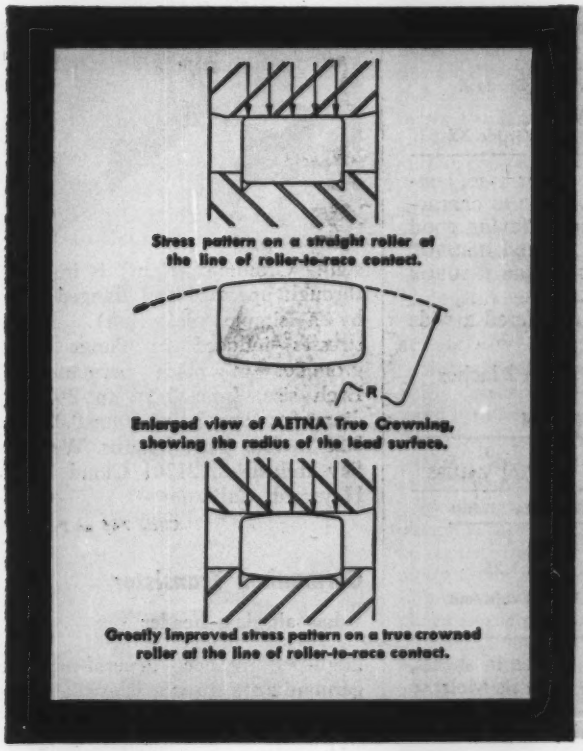
Buy 10%-15% longer bearing life with

Aetna TRUE CROWNED Roller Bearings

Competitive tests of AETNA *True Crowned* Roller Bearings with standard roller bearings by leading machinery builders on identical equipment, with identical load stresses, proved conclusively, time and time again, that AETNA True Crowned Roller Bearings have a 10% to 15% longer service life.

There is no premium for this True Crowned bearing surface. AETNA engineers recommend True Crowned rollers because this design provides the best distribution of stresses across the full length of the roller. You simply buy longer service life at the same cost by specifying AETNA.

The reason for longer bearing life is apparent in these drawings:



Stress pattern on a straight roller at the line of roller-to-race contact.

Enlarged view of AETNA True Crowning, showing the radius of the load surface.

Greatly improved stress pattern on a true crowned roller at the line of roller-to-race contact.

Each roller incorporated into AETNA Roller Bearings is carefully ground to a fine finish with a large radius to relieve the high stress point present where two cylindrical bodies are in rolling contact and under load. The crown radius is scientifically determined and varies with the size of the roller.

AETNA stocks pure radial cylindrical roller bearings, and is equipped to supply pure thrust or special types with standard, precision or super-precision tolerances in special alloys to give longer life to your products. Call your local AETNA representative listed in the yellow pages of your Classified Phone Book, or write today for General Catalog and Engineering Manual—new 15th Edition.

Aetna **AETNA BALL AND ROLLER BEARING COMPANY**

DIVISION OF PARKERSBURGH-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.

IN DETROIT—SAM T. KELLER, 1212 FISHER BUILDING

FOR HIGH SPEED FABRICATION

NEW INSUROK®

Free-Machining, Laminated, Rolled Tubes Meet Mil-P-79B and Federal L-L-31

INSUROK GRADE	NEMA GRADE	MILITARY SPECIFICATIONS	FEDERAL SPECIFICATIONS
T-300	X	Mil-P-79B, Type PBM, Form TR	L-L-31, Type 1, Grade X
T-301	XX	Mil-P-79B, Type PBG, Form TR	L-L-31, Type 1, Grade XX

T-300 and T-301—two new, improved grades of INSUROK paper base, laminated tubes are distinguished by their excellent FREE MACHINING characteristics. They do not chip or delaminate when fabricated. Having good dielectric properties and uniform appearance, these light colored INSUROK tubes are suited to any fabricating operation. You can machine INSUROK T-300 and T-301 at top operating speeds.

For your electrical and mechanical applications you are offered a wide choice of tube sizes in these new grades:

• Inside diameters up to 12 inches • Wall thicknesses up to 2 inches

CHARACTERISTIC PROPERTY COMPARISON

CHARACTERISTIC PROPERTIES	NEMA XX REQUIREMENTS	T-301 TYPICAL VALUES
	Test Samples From 1" x 1¼" Tubes	
Water Absorption	2% maximum	1%
Density (grams per CM^3)	1.12 minimum	1.25
Dielectric Strength (perpendicular to laminations)	290 volts/mil. minimum	400 volts/mil.

Richardson offers a complete line of INSUROK laminated grades in sheets, rods and tubes . . . also provides complete fabrication service at its Melrose Park, Illinois and New Brunswick, New Jersey plants.

For full information on INSUROK T-300 and T-301, write direct or contact sales offices in principal cities.

the RICHARDSON COMPANY

LAMINATED AND MOLDED PLASTICS Founded 1858

2795 LAKE STREET • MELROSE PARK, ILLINOIS • SALES OFFICES IN PRINCIPAL CITIES

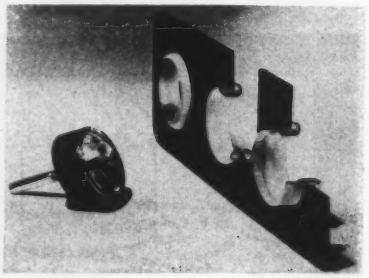
for maximum life. High-speed first gear is fiber for minimum noise, and low-speed gear is bronze for maximum torque. Shaft position is easily changed to six 30-deg positions by means of six screws. Over-all size is 6 x 3 5/16 x 3⅜ in. Units are available in universal, shunt, or series motor with 12 to 220-v input. **Carter Motor Co.**, 2700 W. George St., Chicago 18, Ill. I

Circle 744 on Page 19

One-Piece Grommet

nylon unit is installed without heat

One-piece solid grommet of Zytel 103 nylon, called "Flip Grommet," fits snugly and cannot shake loose or pop out. Nylon wears extremely well and does not chase material. It also provides excellent insulation properties. Grommet is used in temperatures from −65 to 300 F. No heat is needed to in-



stall. Grommet (right) is inserted through aperture and flanged over by a simple tool (left). Hoop stresses induced in flange hold grommet in place permanently. Each size, from 3/16 to 2½ in. diam, fits sheet gages from 0.025 to 0.25 in four basic lengths. **Western Sky Industries**, 21301 Cloud Way, Hayward, Calif. M

Circle 745 on Page 19

Germanium Transistor

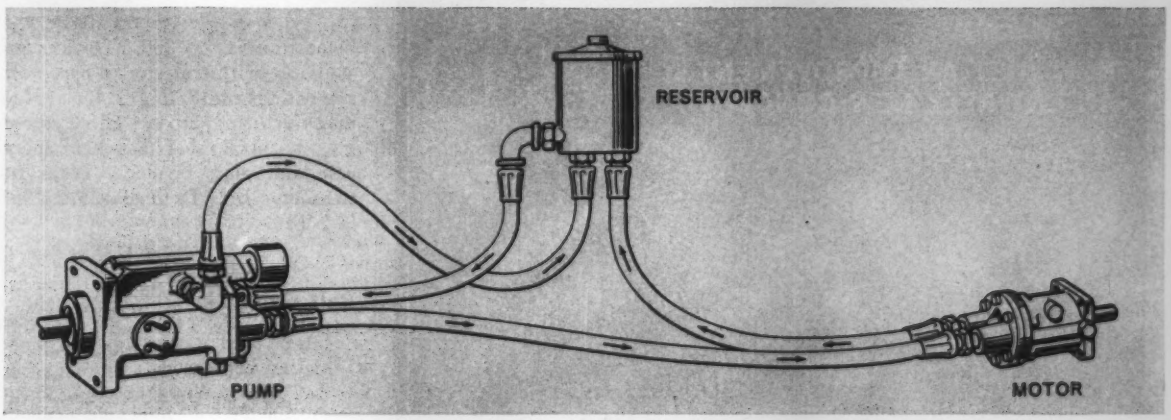
has all-glass header

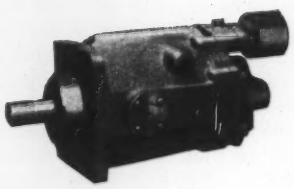
High-performance, general-purpose germanium transistor is available in ten types of industrial P-N-P units. Types 2N1372 through 2N1381 feature 250 mw dissipation, 200 ma collector current, and operation to 100 C. The 2N1380 and 2N1381 have typical dc beta of 100. Types 2N1372 through 2N1379 have dc

Creative hydraulics by Sundstrand

Variable input—constant output speed transmissions designed for mobile equipment

Compact, lightweight, highly efficient hydrostatic transmissions develop up to 9 hp





32 PV Variable Displacement Pump

Reservoir 1½-Quart Capacity

7MC Fixed Displacement Motor

Here's a new idea in boosting efficiency of constant output speed auxiliary operations on mobile equipment. Compact, high-efficiency hydrostatic transmissions designed to use low-cost piston-type pumps and motors are being introduced in six standard sizes by Sundstrand—a company with more than 10 years' experience in constant speed drives.

Principal components of the Sundstrand hydrostatic transmission as shown at the left are: (1) Variable displacement axial piston pump, (2) a fixed displacement axial piston motor, and (3) a small (1½-quart) reservoir. Output horsepower depends on input speed range (see table at right).

Motor speed remains constant within ± 5% despite variations in pump input speed because of the unique control. The pump continually measures its own output and makes adjustments automatically in order to deliver a constant flow of oil.

By adding a small independent manual control to the circuit, pump delivery may be regulated to vary output speed of the motor from zero to maximum RPM. Constant motor output speed is maintained at any particular valve setting.

System is unusually compact and light in weight. There's no spilling of oil over a relief valve or bypassing of oil under pressure as pump delivers only the amount of oil needed. High efficiency is obtained —therefore there is no problem of heat dissipation.

Typical Hydrostatic Transmissions

OUTPUT H.P.	PUMP INPUT SPEED RANGE—RPM	MOTOR CONSTANT OUTPUT SPEED RPM ± 5%*
2 hp	300 to 3000	1200
3 hp	450 to 3000	1800
4 hp	600 to 2500	2400
6 hp	800 to 2400	3000
8 hp	850 to 2300	3300
9 hp	950 to 2200	3600

*Under normal rated load conditions, motor output speed can be held constant within ±5%.

Typical applications for Sundstrand hydrostatic transmissions include: Alternator drives on construction and fire-fighting equipment, refrigeration compressor drives, fan drives in air conditioned buses, and conveyor drives on agricultural, construction and mining equipment.

Sundstrand hydrostatic transmissions can be the answer to your power requirements. Get more facts by sending a brief outline of your needs to address below.

SUNDSTRAND

SUNDSTRAND HYDRAULICS

DIVISION OF SUNDSTRAND CORPORATION

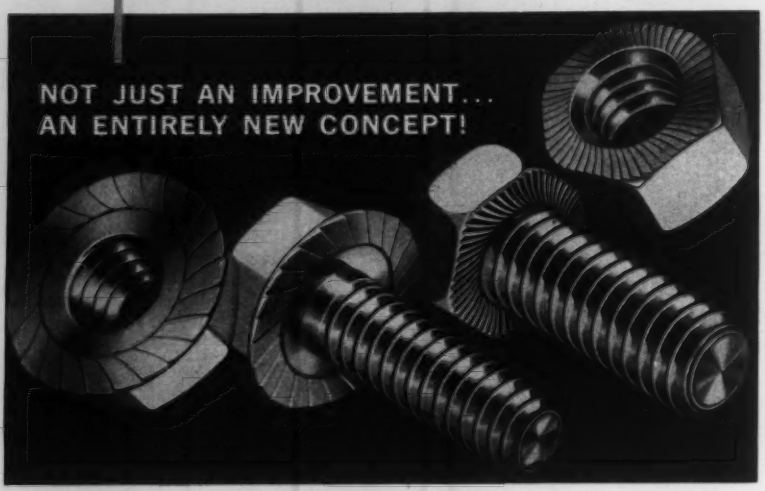
2210 Harrison Ave., Rockford, Ill.—Eastern Sales Office: 89 Summit Ave., Summit, N. J.

AIRCRAFT AND INDUSTRIAL HYDRAULIC TRANSMISSIONS, PUMPS, MOTORS AND VALVES
OIL BURNER PUMPS • AIR SANDERS • LATHES, MILLING, BROACHING AND SPICIAL MACHINES • BROACHING TOOLS • MAGNETIC CHUCKS • PACKAGING MACHINERY

Circle 545 on Page 19

NOW! MF whiz-lock

MORE TENSION–MORE LOCK!



Now *depend* on tension you specify, *depend* on *uniform* tension throughout the assembly. Forget flange clearance requirements. Works equally well on large or small bearing surfaces. No more erratic torque-tension relationship. Excellent electrical contact.

Free spinning—*burr free*—handles as easily as a common nut. Heat-treated—high tensile strength—pre-lubricated—variables eliminated. *Highly reuseable* regardless of surface condition on plated, uneven, drilled or punched holes.

LOW COST, TOO!

Despite the precision manufacturing techniques—and the high degree of quality control necessary in the manufacture of the Whiz-Lock, it is designed to be made on standard machines. *No premium* for this *superior* locking and holding power.

ASK TO SEE THIS AMAZING TEST!

Apply a common nut with as much torque as you can. Torque to release it doesn't even reach application torque. Now spin on a Whiz-Lock, tighten—and try to break it loose!

SCIENTIFICALLY DESIGNED TEETH

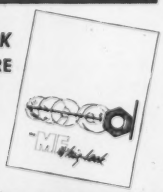
The number, shape and curve of the teeth eliminates variables. Uniform torque-tension and a high "break loose" torque in relation to application torque.

CONVEX ANGLE OF THE BASE

The slightly convex angle achieved through the geometrically correct curve of the teeth allows first contact of the nut to work nearest to the hole. This gives locking strength entirely within the circumference of the nut; will lock on depressed side of punched holes.

DESK-TOP PROOF!

SEND FOR *WHIZ-LOCK* BROCHURE



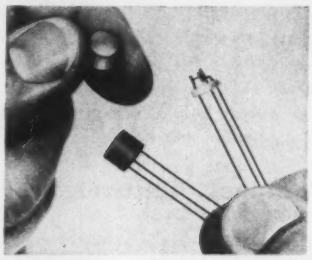
patents pending

Offices in Principal Cities

MACLEAN-FOGG LOCK NUT CO

5535 North Wolcott Avenue
Chicago 40, ED 4-8420

Circle 546 on Page 19



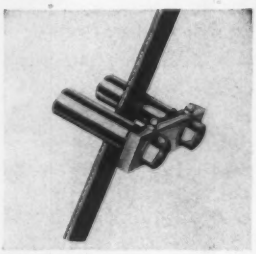
betas from 30 to 300. Devices are available with collector-to-base voltage ratings of 12, 25, or 45 v. New manufacturing process allows direct glass-to-metal seal between metal case and glass header. **Texas Instruments Inc.**, P. O. Box 312, Dallas, Tex. P

Circle 746 on Page 19

Belt Guide

can be used at highest belt speeds

Use of new belt guide effects substantial power saving through reduced slippage, and increases belt life. Guide can be used at highest belt speeds, and requires relubrication only after 20,000 hr operation. Design consists of one roller bearing and one ball bearing fitted in a sleeve so that outer rings remain stationary. Bearings are sealed



against lint and dirt. Elimination of inner rings makes possible a larger, stronger guide. Unit is adaptable to all industries where fork guides for belts are used. **SKF Industries Inc.**, Front St. and Erie Avenue, Philadelphia 32, Pa. C

Circle 747 on Page 19

Elapsed-Time Indicators

subminiature units operate on 60-cps supplies

Subminiature elapsed-time indicators are furnished in three basic models with a variety of mounting arrangements. Intended for opera-

CLARE relays and stepping switches

One of five banks of Clare Type J Relays in P&W Numerical Control. At left, in cylindrical can, a Clare Type HG4 Mercury-wetted Contact Relay.

INSURE ACCURACY, INCREASE RELIABILITY, REDUCE SIZE *of*

PRATT & WHITNEY'S Numerical Control...

Pratt & Whitney's Numerical Control is a fully automatic, ultra-precise means of translating blueprint data into a series of machine positions. Applied to jig borers and other precision Pratt & Whitney machine tools, settings are made quickly, with high reliability to .0001" accuracy.

In operation, the Planning Engineer transfers to a Numerical Planning Chart all dimensional data from the blueprints which are necessary to determine the positions. Ordinary clerical help then punch these data into a tape. Machine positionings are then controlled by the tape or, when required, by a dial on the Operator's Console.

Here is what P&W's Mark H. Sluis has to say about the vital part played by Clare Relays and Stepping Switches:

"In the 4EA Numerically Controlled Jig Borer, punched-tape information is decoded by Clare Type J Relays and fed to a storage bank of 25 Clare Type 11 Stepping Switches. The selection of the proper storage switch is accomplished by a distributor—a Clare Type 26 Stepping Switch. In addition to storing the required command data for the slide positioning of this machine, logic circuitry comprises some 115 Clare Type J Relays.

"For ultra-reliability of the digit-selection circuitry, a dozen Clare Type HG4 four-pole Mercury-wetted Contact Relays are utilized.

"Through use of the Clare relays and stepping switches, our circuitry has increased in reliability, and a large contribution was made which enabled us to realize a 6:1 size reduction of the control system."

Circle 547 on Page 19

A Pratt & Whitney 4EA Numerically Controlled Jig Borer.

For complete information on Clare Relays and Stepping Switches contact C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., P.O. Box 134, Downsview, Ontario. Cable Address: CLARELAY

CLARE RELAYS *First in the Industrial Field*

Eliminate "high-cost specials" by standardizing on

AMERICAN STOCK GEARS

Investigate and you'll probably find that instead of having to go to the added time and expense of ordering special gears, that your needs can be filled from the American line.

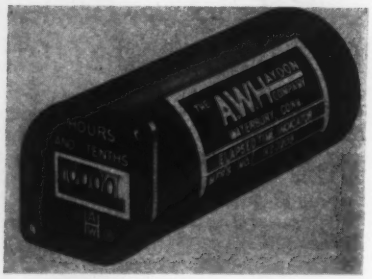
American is a 'complete' stock gear line. Manufactured by Perfection — a veteran of over 30 years in the gear business — these gears are made to the most precise standards, from the highest quality materials. This popular line includes brass, bronze, steel, semi-steel, cast iron, and non-metallic gears in a range of 48 to 3 diametral pitch.

You'll save time and money . . . save on inventory . . . simplify purchasing and have less lost production time by procuring your stock gear needs from your nearby distributor of American Stock Gears.

Ask for FREE copy of American Stock Gear Catalog No. 360 containing detailed information and engineering data.

AMERICAN STOCK GEAR division
Perfection Gear Co., Harvey, Illinois

tion on 115-v, 60-cycle supplies, they include a digital model and two dial-type units. Digital model (shown) has five digits reading to 9999.9 hr in 0.1 hr increments. Two dial types are offered, one reading to 2500 hr in 5-hr increments and one reading to 10,000 hr in 10-hr increments. All models use a miniature 60-cycle motor drawing less than 3 w. Enclosed in a 1¼-in. diam housing, instruments are filled



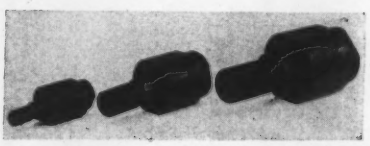
with dry-nitrogen atmosphere and hermetically sealed. Option on mounting flange allows installation to best meet individual application requirements. Reliable operation is assured over voltage range of 105 to 125 v, and over frequency range of 57 to 63 cps. **A. W. Haydon Co.**, Waterbury, Conn. B

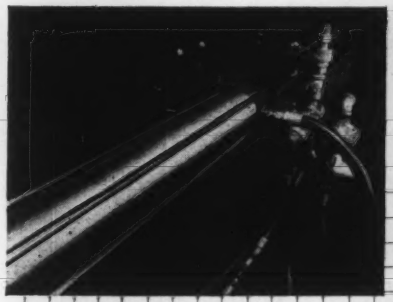
Circle 748 on Page 19

Rod-End Coupler

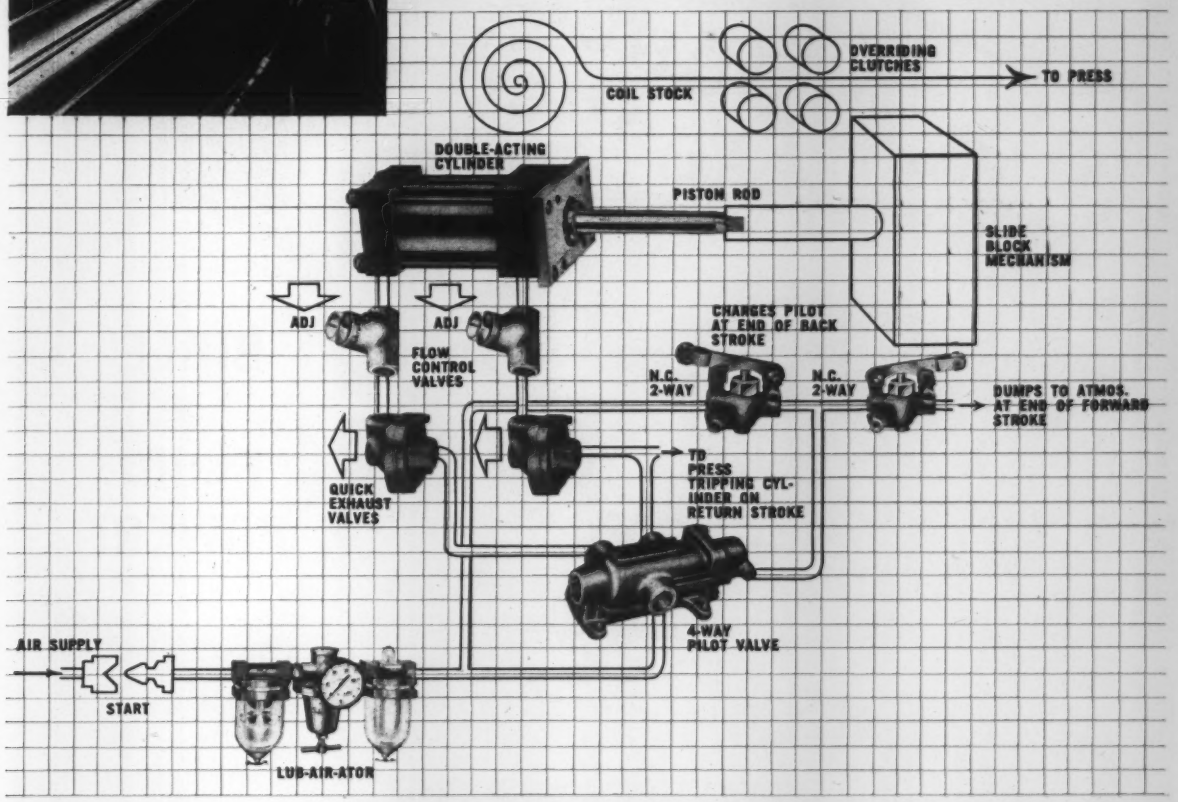
for air and hydraulic cylinders

Self-aligning rod-end coupler insures precision axial alignment between air and hydraulic cylinders and machine. It permits greater machinery tolerances, provides consistently smooth operation free from binding, and compensates for deflection in machinery due to movement of weights. Coupler meets JIC Hydraulic Standard H6.3.2, and also requirements of cylinders with either shouldered external, or internal, thread. Couplers for ⅝, 1, 1⅜, 1¾, and 2-in. diam rods are available in stock, with larger sizes from 2½ to 5½ in. available on





This is an example of how OEM use Schrader. The hookup of Schrader Air Products in the large schematic is used by the Cooper-Weymouth Company of Stratford, Connecticut, to operate its patented power press slide-feed. Power to the mechanism is supplied by a Schrader double-acting cylinder, the front head of which is machined as an integral part of the overriding clutch. At the end of the forward stroke, the slide block operates a normally-closed 2-way valve, which dumps the pilot of a 4-way control valve. This reverses cylinder piston, and the slide block mounted on it, to return for the next stroke. Another normally-closed 2-way valve ahead of the pilot charges the 4-way pilot in a conventional reciprocating motion arrangement to start the next cycle.



ORIGINAL EQUIPMENT MANUFACTURER BUILDS STANDARD SCHRADER AIR PRODUCTS INTO AUTOMATIC TOOLS FOR SPEED, PRECISION

If your company *manufactures* machines or equipment that must push, pull, hold, position or move work repetitively . . . consider the advantages of actuating them with air. Schrader makes complete lines of Air Products that can do such jobs with dependable precision. In limitless combinations, they adapt to many special needs.

Air offers manufacturers much more than versatility. It's fast and accurate, can time to fractions of seconds at high speeds. Its economy alone is a powerful sales point. Safe, tireless, air power is simple that problems of weight, assembly, production and maintenance are enormously reduced.

These are benefits all customers look for. Add them to your products by actuating with Schrader . . . finest, most complete lines of Air Cylinders, Valves and Accessories.

Select from the full Schrader lines to plan your automation of machines. Your Schrader distributor can help you pinpoint what you need. For more data write:

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476 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

You will find this complete and factual material extremely valuable for planning a modern hydraulic circuit! Written by engineers long experienced in fluid power design, this new 8½ x 11 book shows operations and applications of all pressure controlled valves — relief, sequence, reducing, unloading and counterbalance.

A helpful guide to selecting the proper valve for the job, Rivett's new Catalog No. 230 discusses in detail all factors influencing correct choice: normal spool position, operating pressure source, pilot or direct operation. Also shown are flow diagrams, pressure vs. flow curves, ratings, dimensions, drawings and specifications.

For your free copy of Catalog No. 230, write on company letterhead to

RIVETT, INCORPORATED, DEPT. MD9
Brighton 35, Boston, Massachusetts

RIVETT furnishes a complete power package

AIR AND HYDRAULIC — VALVES, CYLINDERS, POWER UNITS

Member—National Fluid Power Association

special order. Surfaces of coupler are black-oxide finished after through-hardening to Rockwell C 50-54. **Hydro-Line Mfg. Co.**, 5600 Pike Rd., Rockford, Ill. K

Circle 749 on Page 19

Solenoid Valve

small unit
handles any fluid

No. 31-2294-000 solenoid valve, with total weight of 0.21 lb, is adaptable to a variety of sizes and configurations. The 400-cycle, nonrectified ac unit handles any fluid such as solvents, hydraulic fluids,

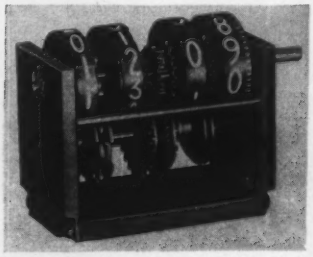
fuels, or hot gases. It performs jobs expected of larger, heavier units of the same type. **Aero Supply Mfg. Co. Inc.**, Corry, Pa. F

Circle 750 on Page 19

Clock-Type Counter

provides large
numeral readout

X-950 clock-type counter provides 24-hr indications in minutes and hours for elapsed-time readout applications. White, 1/4-in. characters on black drums present easily read time information. Unit shown provides continuous and reversible operation from zero to 23 min, 59 sec. Operable at speeds to 300 rpm for zeroing purposes, normal operating speed of unit is 0.1 rpm at input shaft. One revolution of shaft provides 10 min indication. Counter is for use in temperatures from −30



ALL NEW . . . through and through!

*Also available as a self-contained driving head for use in specially designed assembly machines.

The DPS model U power screwdriving machine

Manufacturing assemblies with small parts? Take note! Detroit Power Screwdriver Company announces the totally new Model U—quickly adaptable for fast, clean driving of screws, nuts and studs.

Scores of advances! An adjustable clutch designed to hold constant driving torques. A hopper drive with built-in slip control to accommodate shock loads. A feed track with quickly adjustable covers, and an escapement mechanism with positive solenoid action permitting release of screw by body or head.

A new folder, too. Write for your copy today.

DETROIT POWER SCREWDRIVER COMPANY 19.033
2801 W. Fort St. • Detroit 16, Michigan
A Subsidiary of Link-Belt Company

Circle 551 on Page 19

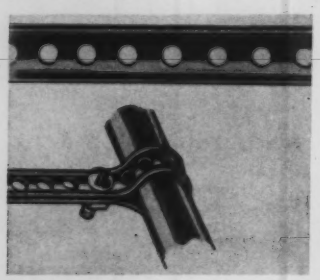
C, where input torque is 0.75 oz-in., to +71 C. **Bowmar Instrument Corp.**, 8000 Bluffton Rd., Ft. Wayne, Ind. J

Circle 751 on Page 19

Nylon Strapping

is now available in ⅝-in. width

Nylon strapping, 0.07 in. thick, is now furnished in ⅝-in. width in 25 and 50-ft rolls. Strapping is furnished either plain or with continuously spaced center holes, in black or natural color. Material is tough, lightweight, flexible, and chemically resistant. It can be employed safely in temperatures from −60 to 250 F. Strapping serves for random-size cable clamps and hangers for wiring, tubing, fragile objects, switches, and other components. Both ⅜ and ½-in. widths are also offered in natural and black color. **Weckesser Co.**, Dept. MD-1, 5701 Northwest Highway, Chicago 46, Ill. J

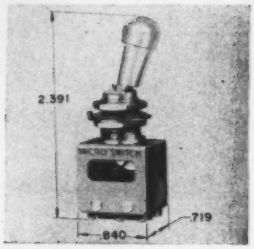


Circle 752 on Page 19

Toggle Switches

are pull-to-unlock type

Series 13AT precision toggle switches require less behind-panel space than other similar switches. They feature a positive-lever locking device as an integral part of switch. Device holds toggle lever in a set position and requires definite pull of approximately 0.09 in. to change from one position to another. Accidental toggle lever movement is prevented. Series is available in a variety of combinations, from two through four-pole units, with or without gold contacts and/or turret-type terminals. Each switch in an assembly has an SPDT snap-contact



arrangement. Switches are rated at 5 amp 250 v ac. The 30-v dc rating includes: Inductive, 3 amp at sea level and 2.5 amp at 50,000 ft; resistive, 5 amp at sea level and 50,000 ft. Maximum inrush is 24 amp. Switches are suitable for aircraft, mobile, marine, and electronic applications. **Micro Switch Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill. K

Circle 753 on Page 19

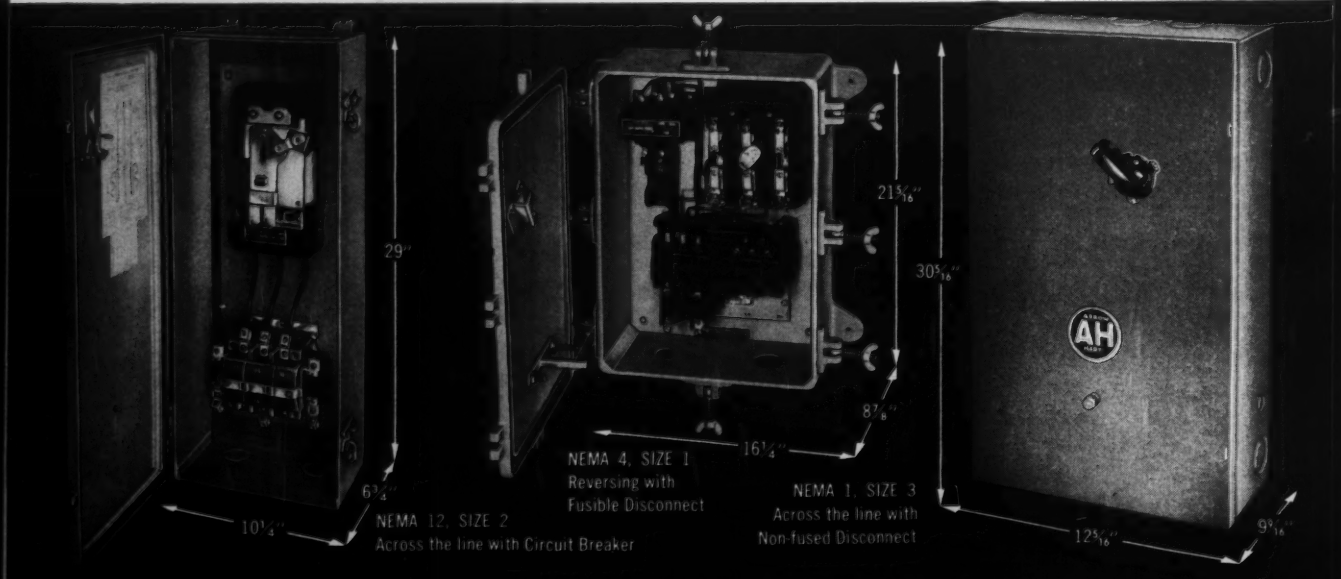
Polyethylene Compounds

resist dust attraction

Bakelite polyethylene compounds eliminate dust attraction by injection-molded articles, since they do not retain electrical charge which attracts dust. Materials possess all

ARROW AH HART

Announcing: A COMPLETE LINE OF COMBINATION STARTERS UP TO 100 HP, 440 VOLTS AC NEMA SIZES 0, 1, 2 and new sizes 3 and 4



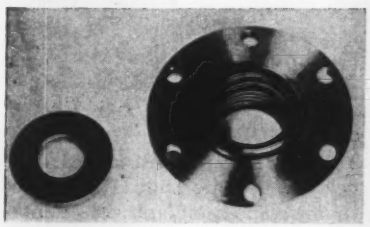
other desirable properties of high-quality polyethylene housewares compounds. DPD-7366 has excellent low-temperature toughness and improved rigidity, in addition to antidust properties. DNDA-0401 is a high-flow, general-purpose, antidust housewares material with less rigidity than DPD-7366 in molded housewares items. **Union Carbide Plastics Co., Div., Union Carbide Corp.**, 420 Lexington Ave., New York 17, N. Y. C

Circle 754 on Page 19

Bellows Seal

all-metal unit is for severe conditions

Designated Series AMB, new all-metal, bellows-type mechanical shaft seal is for use in aircraft, missile, rocket, industrial, and process rotating machinery systems. Unit operates in severe environments of corrosion, and critical temperatures and pressures. It operates effectively at pressures to 1000 psi, speeds to 36,000 rpm, and between temperatures of −400 to 1000 F. Seal resists most corrosive bases and acids, both liquids and gases, and provides leakproof sealing of hazardous fluids such as liquefied gas and hydrocarbon fuels. It achieves balanced hydraulic loading and can be temperature cycled without impairing performance. Seal is available in sizes to 7 in. shaft diam, and can be supplied to meet special requirements for any type of compressor, turbine, or pump. **Turbocraft Inc.**, 492 E. Union St., Pasadena, Calif. L

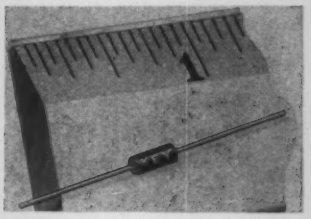


Circle 755 on Page 19

Wire-Wound Resistors

for transistorized circuits

Precision wire-wound resistors are rated to 125 C full load, and can be operated at full load with no derating. Smallest units, Series 20, have diameter of 0.1 in. and length of 0.25 in., with values from 10 to 150,000 ohms. Resistors are especially suited for transistorized circuits. Units operate reliably when exposed to severe physical environment. They exceed performance requirements of MIL-R-93C Proposed. **Key Resistor Corp.**, 321 W. Redondo Beach Blvd., Gardena, Calif. L



Circle 756 on Page 19

Adjustable-Speed Drive

has separate motor construction

Mechanical adjustable-speed drive is available with ratings of ½ to 30 hp, output speeds from 4660 to 1.2 rpm, and speed variations from 2:1 to 10:1. Drives feature separate mo-

MOTOR CONTROLS

New NEW WEATHERPROOF and EXPLOSIONPROOF ENCLOSURES WEIGH ONE-HALF AS MUCH AS CONVENTIONAL BOXES

Offering Weatherproof and Explosionproof enclosures of strong, cast aluminum, *one-half the weight of old-style cast iron boxes.* Choice of fused or unfused Disconnect Switch or Circuit Breakers.

ENCLOSURES FOR EVERY USE:

- General Purpose – NEMA TYPE 1
- Weatherproof – NEMA TYPE 4
- Explosionproof – NEMA TYPES 7 and 9
- Industrial (oiltight and dust resistant) – NEMA TYPE 12

AVAILABLE:

- Non-Reversing, Reversing and Two-Speed Types
- In NEMA SIZES 0 through 4
- Front operated by means of Fused or Unfused Disconnect or Circuit Breaker. Circuit Breakers are Instantaneous or Thermal Magnetic Trip Types.
- With or Without Control Circuit Transformers

"RIGHT ANGLE" DESIGN STARTERS:

- Straight-Thru Front Wiring • Epoxy-Resin Encased Coils
- Large, Long-Life Contacts • Easy Maintenance Proved Dependability

Write today for engineering details on Arrow-Hart's complete lines of Combination Starters to: The Arrow-Hart & Hegeman Electric Co., Dept. MD, 103 Hawthorn St., Hartford 6, Conn.

ARROW-HART of HARTFORD

Quality since 1890

MOTOR CONTROLS • ENCLOSED SWITCHES • APPLIANCE SWITCHES • WIRING DEVICES

Circle 553 on Page 19

versatile

pumping power

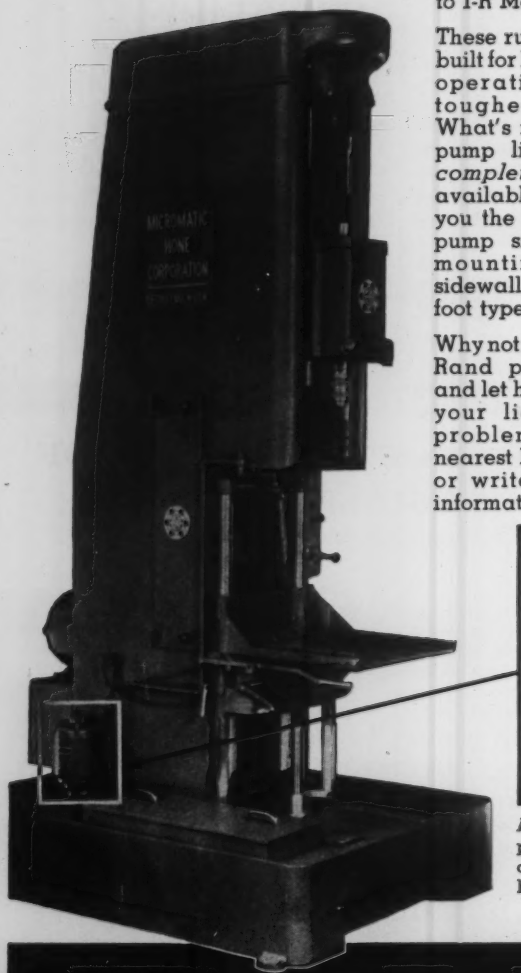
with dependable

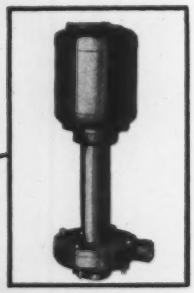
MOTOR PUMPS

The efficient handling of coolant, cutting oils and washing liquids in modern production equipment calls for maximum pumping efficiency. And to solve the various problems in all types of equipment, designers today look *first* to I-R Motorpumps.

These rugged pumps are built for long, trouble-free operation under the toughest conditions. What's more, the Motorpump line is the most *complete* line of pumps available today, offering you the widest choice of pump sizes, types and mountings including sidewall, immersion or foot type.

Why not call an Ingersoll-Rand pump specialist and let him help you with your liquid handling problems. Call your nearest I-R branch office or write for complete information.

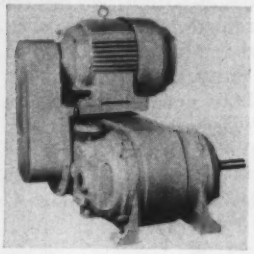




An immersion type Motorpump handles abrasive coolant on a modern honing machine.

9-820

Ingersoll-Rand / 11 Broadway, New York 4, N. Y.



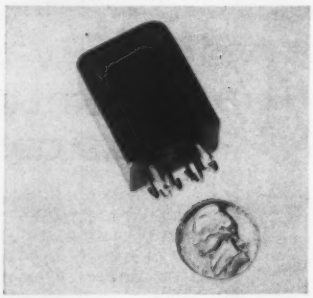
tor construction and horizontal assembly. Wide selection of infinitely variable output-speed ranges is realized through proper selection of V-belt and timing belt. Dripproof, totally enclosed, explosionproof, and a variety of other special motors are available. **Sterling Electric Motors**, 5401 Telegraph Rd., Los Angeles 22, Calif. L

Circle 757 on Page 19

Time-Delay Relays

provide delays from 0.05 to 90 sec

Microminiature, transistorized time-delay relays are suited for printed circuits and miniaturized components. Each of four different models weighs only 2 oz and measures 1.25 cu in. Time delays between 0.05 and 90 sec can be provided, and slight increase in size allows delays to 950 sec. Accuracy ranges between



±5 and ±20 per cent. Operating voltages are between 18 and 50 v dc. Temperature range is −55 to +71 C. **Electronics Div., Hydro-Aire Co.**, 3000 Winona Ave., Burbank, Calif. L

Circle 758 on Page 19

Zippered Tubing

is now furnished in colors

Colored Zippertubing permits ready identification of cable, pipe, or conduit. It is available in five colors,

This G/W Techniplanner kit includes molded thermoplastic parts for a wide diversity of office "space control" layouts.

In Precision Molded Thermoplastics

by *Quinn-Berry* of Course

Bringing to life before the customer's eyes his complete office layout, The Globe-Wernicke Co. uses these Quinn-Berry precision molded thermoplastic scale models. G/W sales engineers say, "Space Control here becomes a reality—one look replaces a thousand words".

Of course successful production of these precision parts requires careful choice of the correct thermoplastics, skillful mold design, dependable press room craftsmanship. These capabilities have gained for Quinn-Berry its enviable reputation as resourceful molders of precision thermoplastic parts—a reputation which invites the unusual. Place your component parts requirements with Quinn-Berry where the Unusual is Routine.

CHELSEA 50, Mass.
Joseph Leader
68 Marlborough Street
Chelsea 3-3484

CHICAGO 45, Illinois
R. H. Frish
Room 211
6349 N. Western Ave.
Ambassador 2-6005

DETROIT 35, MICH.
Harry R. Brethen Co.
16577 Meyers Road
Diamond 1-3454

EAST ROCHESTER, N. Y.
Dynatherm, Inc.
607 West Commercial Street
Phone: Ludlow 6-0082

KNOXVILLE, Tennessee
Harold J. Melloy
2100 Ailor Ave.
P. O. Box 3207
Phone: 2-5911

MILWAUKEE 13, Wis.
John Weiland, Jr.
7105 Grand Parkway
Greenfield 6-7161

ARDMORE, Pa.
Austin L. Wright Co.
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HOLTZER -CABOT

Synchronous and Induction Capacitor Type Motors

R-24. Typical applications for this reversible, 4-pole induction motor are in servo mechanisms, as a balancing motor in recording instruments or as a control motor for voltage regulators. It has low rotor inertia for fast response applications. When operated 2 phase, it can be controlled electronically; or operated single phase as a permanent split capacitor motor.

R-25. Typical uses are for recording instruments, dictating and adding machines. Approximately 2½" in diameter, it is available in either induction or synchronous construction with reversible rotation.

Both the R-24 and R-25 are available with gear case speeds from 1/2 to 3600 RPM, torque ratings up to 75 oz. inches or higher, and single phase, 2 or 3 phase.

HOLTZER-CABOT MOTOR DIVISION
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston 19, Mass.

GENTLEMEN: Please send me data sheets on the Holtzer-Cabot R-24 and R-25 Size Motors.

Please have representative call _____ (date)

Name _____

Company _____

Street _____

City _____ Zone ____ State _____

Circle 556 on Page 19

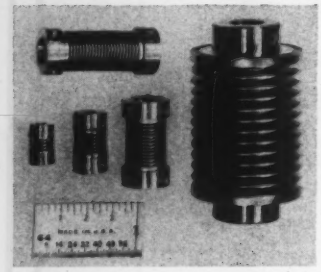
all bright and distinct so that they are easily identifiable when lighting conditions are poor. Tubing can be zipped open, permitting accessibility to conductors, or can be permanently closed. Tubing is furnished on special order with contrasting-color center sections, making possible innumerable color combinations. Zippertubing Co., 752 S. San Pedro St., Los Angeles, Calif. L

Circle 759 on Page 19

Miniature Couplings

are fully flexible

Particularly suited to servos and computers, flexible couplings as small as 0.125 in. OD by 0.245 in. long are available. Couplings are fully flexible in smallest sizes, because bellows provide wall thinness as low as 0.0007 in. Couplings are



supplied in torques from 0.1 to 250 oz-in., with side thrusts from 1 gram at 0.005 in. offset, and twist angles of less than 0.3 deg in all sizes. Servometer Corp., 222 Main Ave., Passaic, N. J. D

Circle 760 on Page 19

Compressed Air Combination

miniature unit is fully automatic

Combination separator, regulator, and lubricator provides maximum protection of all compressed-air operated equipment such as air tools and air cylinders, and permits only dry, regulated, lubricated air to reach equipment. Unit is fully automatic, eliminating need for manual draining. Separator (left) activates with each cycle of air, automatically discharging accumulated moisture and sludge into atmosphere. Regulator (center) is self-relieving and equipped with three "out" ports. They are available in 0 to 50 and 5 to 125 psi pressure ranges, with

The Second Annual

INSTRUMENT MOTOR SYMPOSIUM

sponsored by

Holtzer-Cabot Motor Division

National Pneumatic Co., Inc. will be held in Chicago during the week of the ISA Instrument-Automation Conference and Exhibit.

Theme: "Today's Trends — Tomorrow's Motors"

Speakers: Nationally-known instrument and motor design specialists. Open discussion will follow the prepared remarks.

When: 8:00-10:00 p.m., Tuesday, September 22.

Where: Palmer House, Chicago

How to Register: Members and guests of the ISA may register at Holtzer-Cabot's exhibit (#368) at the International Amphitheatre on Monday or Tuesday or by writing earlier to the Symposium Chairman: R. H. Matthews, Chief Engineer, Holtzer-Cabot Motor Division, National Pneumatic Co., Inc., 125 Amory Street, Boston, Massachusetts.

Circle 557 on Page 19

PRECISION SEALS
engineered to your product
CUT COSTS

PROBLEM Solving is a common occurrence at Precision. One was the development of a universal compound for automatic transmissions and power steering systems. **THE SOLUTION**—Precision Compound No. 6767—provided an "O" Ring with these characteristics. Suitable for all transmission fluids . . . particularly type "A" . . . long life over a temperature range of −40F to 300F . . . excellent resistance to cracking . . . low volume change . . . low compression set . . . high modulus. Precision creative research has reduced costs by producing the right "O" Ring for many manufacturers. You can benefit too, for the services of a Precision engineer are available to help you obtain the right product design and the right "O" Ring for it. Write or phone for his services today.

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"O" Ring and Dyna-seal Specialists

Box 431, Oakridge Drive, Dayton 7, Ohio **Canadian plant at: Ste. Thérèse de Blainville, Québec**

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Big switch features in small switch size

NEW DENISON LOXSWITCH MODEL M LIMIT SWITCH

Tested to over 45,000,000 cycles under electrical load

- Heavy duty nylon latch mechanism
- 3/8" wide contact gap
- Two completely isolated circuits, 1-NO, 1-NC
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- Plug-in convenience—or direct wiring
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- Light actuating force—45 oz./in.
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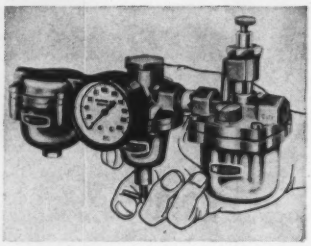
FREE—4-page folder gives complete dimensions, specifications, prices, lever styles, boxes. Write for Bulletin M-1, R. B. Denison Mfg. Company, 386 Broadway, Bedford, Ohio

DENISON

LOXSWITCH

Wire with LOXSWITCH and you wire for good!



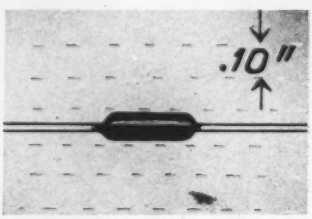
minimum pressure drop. Lubricator (right) starts lubricating at 1 cfm and delivers oil fog to as many tools as air itself will serve. Unit can be filled without shutting off air pressure. Combination is available in 1/4 in. NPT. **Wilkerson Corp.**, 1646 W. Girard, Englewood, Colo. K

Circle 761 on Page 19

Miniature Capacitors

are only 0.095 in. wide

Subminiature ceramic capacitors, called Narrow-Caps, are available in capacitance values of 100, 250, 500, 750, and 1000 mmf, with ±20 per cent tolerance. They are only 0.095 in. wide to fit within 0.1-in. modular spacing. Body length of the first four sizes is 0.25 in., and length of 1000-mmf unit is 0.3 in.



max. Temperature range is −60 to +125 C, and power factor is less than 2.5 per cent. No. 26 tin copper gage leads have minimum length of 1½ in. **Mucon Corp.**, 9 St. Francis St., Newark, N. J. D

Circle 762 on Page 19

Appliance Motors

lightweight units have increased motor outputs

Appliance motors, called Power-Line, produce 20 per cent more motor output than previous design, and are 13 per cent lighter. Motors are available in ratings from 1/6 through 1/3 hp, split phase and capacitor-start, 115 or 230 v. Sealed lubrication system eliminates need

HIGH WALLED ?

How long since you have re-evaluated the wall height on your cup packings? Frequently IPC encounters "prints" which call for excessive wall height . . . *and* this extra depth can cause headaches.

Unnecessary wall height can only add to friction and make your cups run "hotter" . . . Torque increases . . . Toe-in is enhanced. Unless there is some unusual factor involved, IPC can recommend a more functional design without these built-in hazards.

Elaborate hide selection combined with IPC "custom treats" and IPC's square shouldered design mean your leather packings and oil seals are started "right". For the finishing touch, IPC offers the last word in quality controlled manufacture.

Let us analyze your leather packings. Perhaps we can tailor a design that will fit your application perfectly.

OIL SEALS
PACKINGS
PRECISION MOLDING
Custom designed
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IPC

INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

P3

What's more important to you

QDP or PDQ?*

Whirlpool Corporation reports: among 598, 265 components supplied by Amplex the first 4 months of 1959, there were only 5 rejects!

Quality, Delivery, Price... this Amplex philosophy enables our customers to cut their production and warranty costs.

The "Price" vendor with poor quality will increase your costs.

Amplex prices are low but cost-saving quality always comes first. A quality record of 99.999992% is the reason why Whirlpool Corporation says, "Quality is our business, too. That's why we purchase components from Amplex."

Contact your local Oilite® representative today. Reduce your costs with quality-controlled Oilite Precision Parts and Bearings. See "Bearings" in the Yellow Pages or write to Dept. S-9.

* *Quality-Delivery-Price vs. Price-Delivery-Quality*

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SINCE 1929 — A CHRYSLER PRODUCT — OILITE

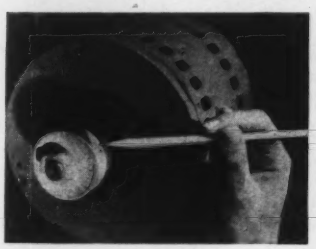
the most trusted name in powder metallurgy!

AMPLEX DIVISION

CHRYSLER CORPORATION, DETROIT 31, MICHIGAN

PRECISION PARTS • SELF-LUBRICATING BEARINGS • METAL FILTERS • FRICTION UNITS

Circle 561 on Page 19



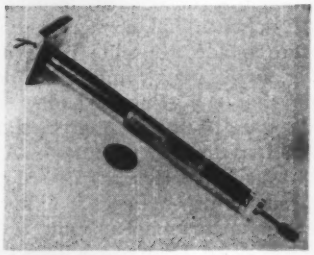
for oiling hole. All-position sleeve bearings in conjunction with sealed lubrication system permit motor to be mounted in any position. End play of shaft has been cut from 0.032 to 0.016 in. to increase bearing life and decrease belt wear and vibration. Motors ventilate from both ends and dissipate more than 6 w per deg C temperature rise. Three end-bell designs provide versatility of application. **Westinghouse Electric Corp.**, Box 2099, Pittsburgh 30, Pa. F

Circle 763 on Page 19

Rectilinear Potentiometer

is ½-in. unit with strokes to 8 in.

RP35 rectilinear potentiometer is suitable for exacting telemetering and control applications in missiles and aircraft. The ½-in. unit is built into a stainless-steel, pressure-sealed case with stainless-steel pushrod. All-metal construction withstands temperatures from −65 to +400 F.



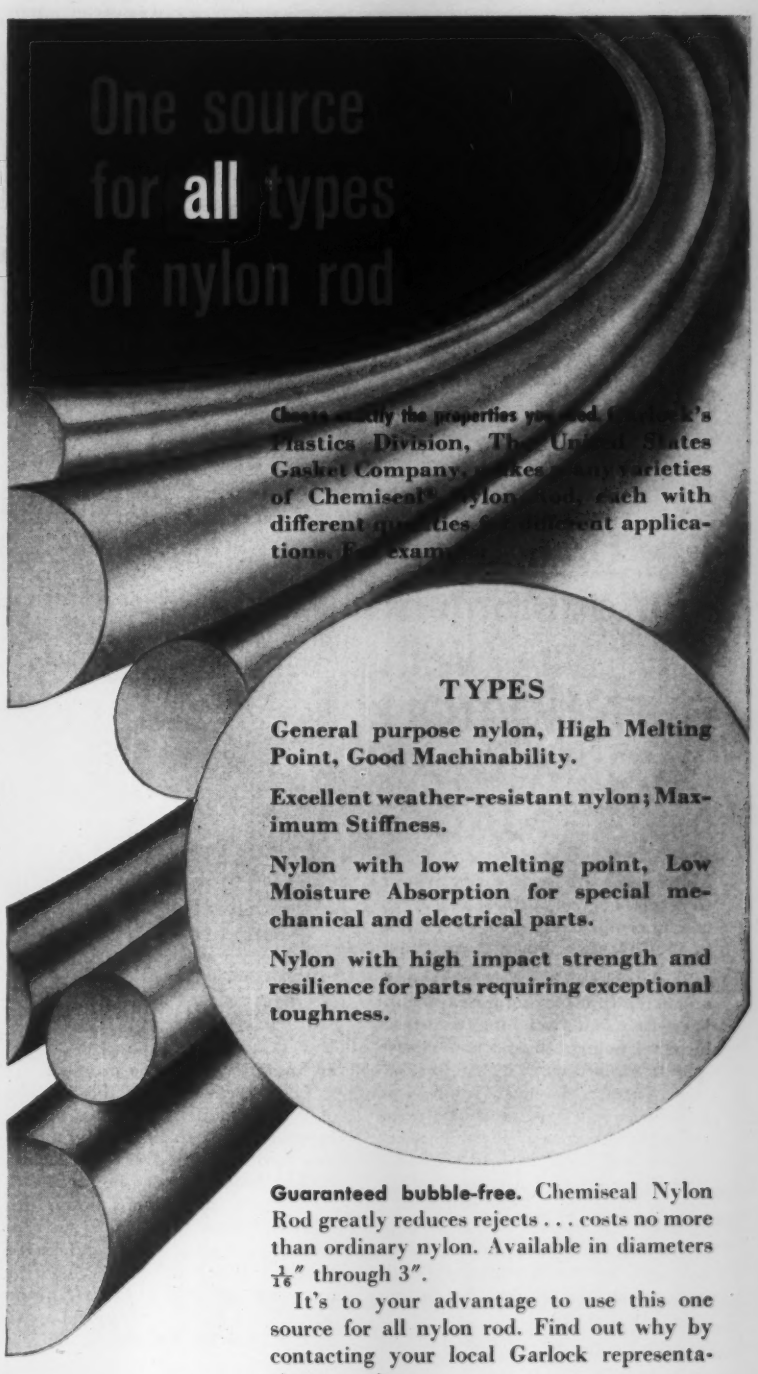
Series is available in strokes to 8 in., and resistance values from 500 to 20,000 ohms can be furnished. **Humphrey Inc.**, 2805 Canon St., San Diego 6, Calif. L

Circle 764 on Page 19

Centrifugal Blower

cools electronic equipment

Air Unit No. 89C21 is designed for commercial applications. It is especially suited for cooling electronic



Guaranteed bubble-free. Chemiseal Nylon Rod greatly reduces rejects . . . costs no more than ordinary nylon. Available in diameters $\frac{1}{16}$" through 3".

It's to your advantage to use this one source for all nylon rod. Find out why by contacting your local Garlock representative, or write

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

United States Gasket

Plastics Division of GARLOCK

Circle 562 on Page 19

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66v.

DUFF-NORTON COMPANY

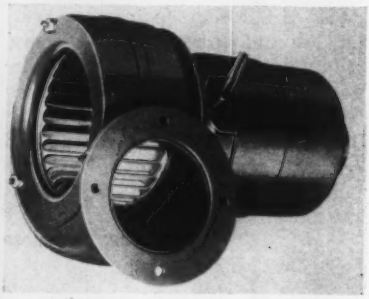
P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric

tubes, ventilating small electronic equipment cabinets, and cooling hot spots. It is recommended for applications where nominal ambient-temperature conditions can be anticipated. Blower parts are die-formed steel. Unit can be furnished with flanged outlet and mounting stand if required. The 1/40-hp, shaded-pole electric motor is of unit-bearing type and does not require oiling. It operates at 3000 rpm using 115-v, single-phase, 60/50-cycle or 230-v, single-phase, 60/50-cycle current.



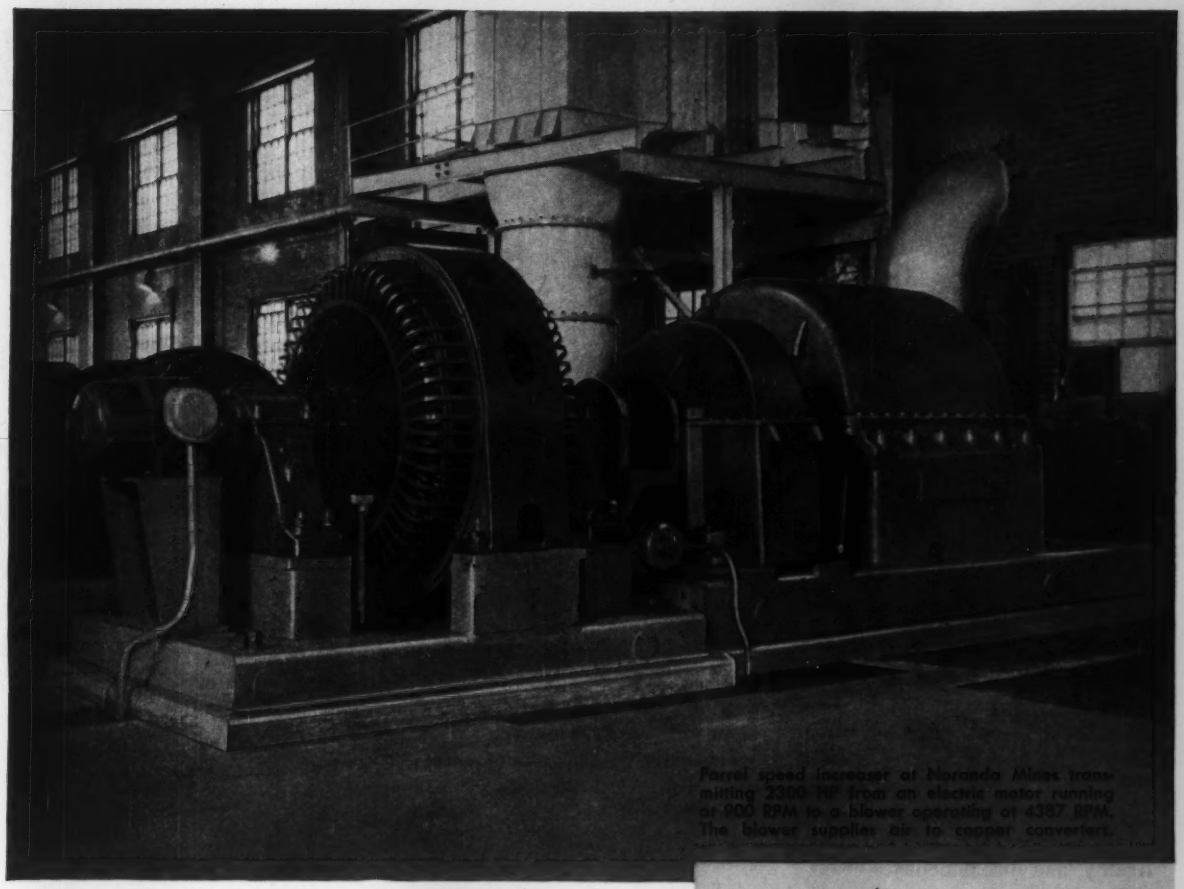
Dimensions are approximately 6 x 6 x 8½ in. **Industrial Div., American-Standard,** 8111 Tireman, Detroit 32, Mich. H

Circle 765 on Page 19

Panel Instruments

mount to ASA C39.1-1955 specifications

Rectangular-shaped, 4.5-in. panel instruments, designated Models 1751, dc, and 1752, ac rectifier type, feature molded Bakelite bases and covers with glass windows, lance-type pointers, 4-in., 100-deg arc scales, and self-shielding mechanism. Instruments mount to ASA C39.1-1955 specifications. Model 1751 dc units—ammeters, milliammeters, microammeters, and voltmeters, offer accuracy within ±2 per cent of full scale. Model 1752 ac instruments offer accuracy within ±3 per cent of full scale when used



Farrel speed increaser at Noranda Mines transmitting 2300 HP from an electric motor running at 900 RPM to a blower operating at 4387 RPM. The blower supplies air to copper converters.

"Both speed increasers have given us very satisfactory service"

These are the words of L. O. Cooper, plant engineer for Noranda Mines, Limited, Noranda, Quebec. He is referring to their two Farrel gear units, used to transmit power from electric motors to high-speed blowers.

Farrel gear units have the benefits of sound engineering, skilled workmanship, high quality materials and years of experience in furnishing speed increasing units which have provided "very satisfactory" service for an indefinite period. In fact, since they were first developed in 1932, not one has ever been known to be replaced.

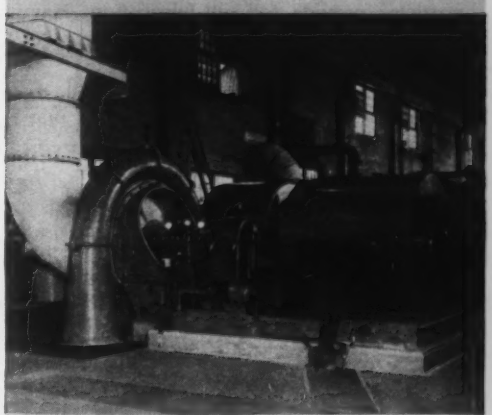
For full details of Farrel speed increasers, send for a copy of bulletin 451.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, Boston, Akron, Ann Arbor (Mich.), Chicago, Minneapolis, Los Angeles, Salt Lake City, Tulsa, Houston, Fayetteville (N. C.)
European Office: Piazza della Republica 32, Milano, Italy

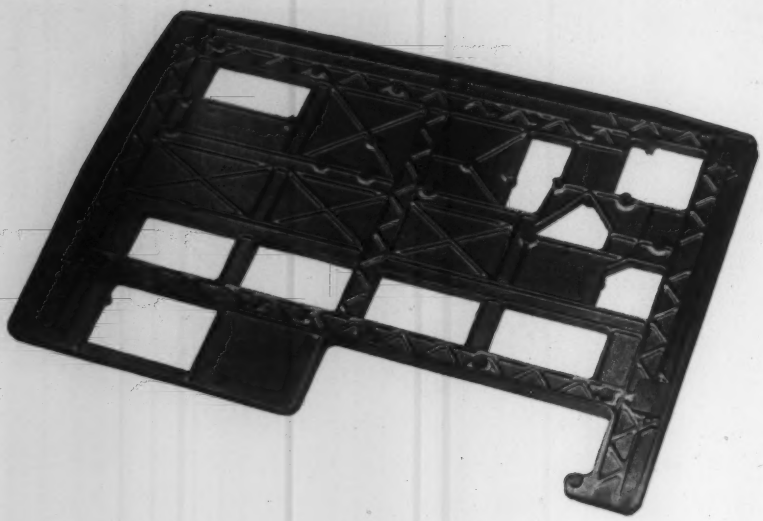
FARREL

NORANDA MINES, LTD.



This 920 HP unit increases speed from 1450 to 4087 RPM. The blower furnishes secondary air to a copper reverberatory furnace.

FB-1160



DUCTILITY

A CASE IN POINT—This ninety-six pound casting was made for the National Cash Register Co. of Nodulite®, Hamilton Foundry's ductile iron. The casting forms the base for the new Post-Tronic Accounting Machine. It measures 37½" by 23½" with sections varying from ¼" to 1½". Ductile iron was chosen for this part because of its ductility, dimensional stability, rigidity, and machinability.

Ductile iron has most of the engineering advantages of steel yet it can be designed with the same flexibility and cast with the same procedures used for gray iron. It has high strength: up to 120,000 psi minimum tensile strength in standard grades. It is tough: Charpy impact strengths up to 115 ft.-lbs. in standard grades. It is ductile: elongation is possible up to 25% after short time annealing. And it is wear resistant: spheroidal graphite particles provide for self-lubrication. Hamilton Foundry regularly casts 60-45-10, 80-60-03, 100-70-03, and 120-90-02 grades of ductile iron as well as high alloy Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules —will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

HAMILTON FOUNDRY INC.

1551 LINCOLN AVENUE • HAMILTON, OHIO • TWinbrook 5-7491

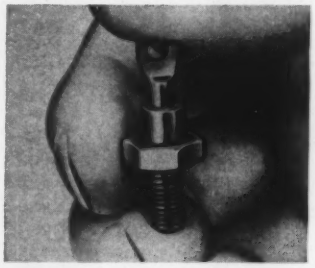
on sine-wave 60-cycle source at normal room temperature of 25 C. Ranges for dc units are 50 mu amp through 10 amp (self-contained) beyond which external shunts are provided. Ranges for ac instruments are 200 mu amp through 5 ma and up to 300 v self-contained. **Daystrom-Weston Sales Div., Daystrom Inc.**, 614 Frelinghuysen Ave., Newark 12, N. J. D

Circle 766 on Page 19

Silicon Rectifier

for current levels from 1 to 15 amp

Style 20 silicon power rectifier is a fused-alloy device with maximum height of 1 3/16 in. It operates at current levels from 1 to 15 amp (single-phase half-wave average). Surge ratings are 90 amp average at 6 cycles (0.1 sec) and 50 amp average at 60 cycles (1 sec). Peak inverse voltages range from 50 to



400 v in 50-v steps. Temperature range is −65 to +175 C. **Syntron Co.**, 260 Lexington Ave., Homer City, Pa. F

Circle 767 on Page 19

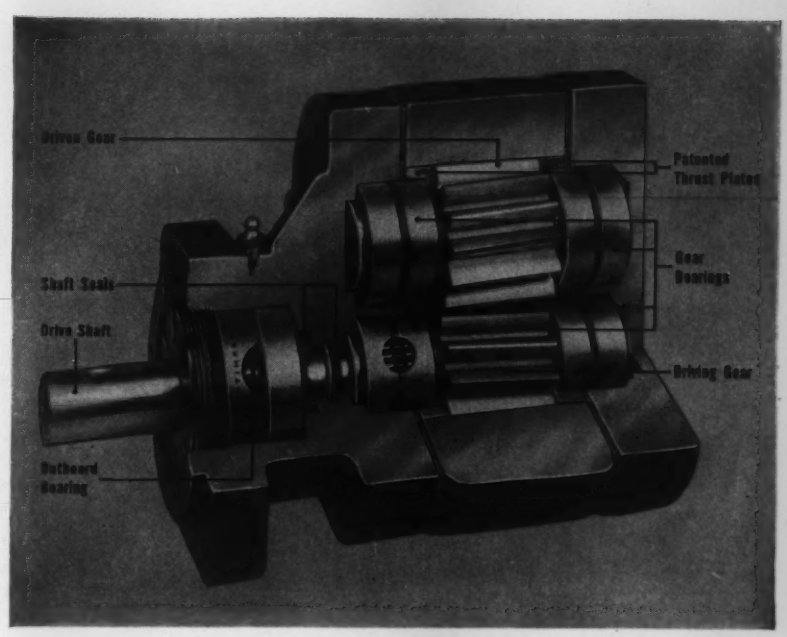
Indexing Drive

has high torque output

Indexing drive unit is available in a number of models to provide speeds to 1000 indexes per minute and output torque ratings of 1100 lb-in. and up. Designed for high-speed, precision indexing, unit utilizes hardened and ground tool-steel cam with preloading of roller-bearing followers. In dwell position, preloaded followers provide zero backlash. Indexing accuracy is held to within 0.001-in. on 12-in. circle. Modified trapezoid acceleration gives jerkfree start and stop of motion and minimum force on cam followers. Standard models are available with

Circle 565 on Page 19

ADVANCES IN HYDRAULIC PUMP DESIGN



Oil leakage controlled

In any method of mounting an oil-hydraulic pump there is always a certain amount of misalignment between the pump drive shaft and the shaft on the power source. Even where universal drives are utilized there is still the danger of a thrust load. Result in both cases: Flexing is transmitted into the pump seal and eventually to the bearings supporting the gear—leakage around the shaft is a sure-fire bet to follow.

At Commercial, by using an outboard bearing to protect the seals and internal bearings, the common leakage nuisance is eliminated.

Internal alignment perfected

Mass production of independent gear pump housing parts invariably results in varying degrees of internal misalignment—regardless of dowel pin control points used in machining. In many cases the "out" for the problem involves a loosening up on the internal tolerances—with a resultant loss in efficiency.

At Commercial, the patented thrust plate serves as a "natural" alignment control point—is counter bored on its face to match the bearing sleeve, then fits over the bearing sleeve and in turn pilots inside the gear housing. Perfect internal alignment—and increased efficiency—in any Commercial oil-hydraulic pump is axiomatic with rigid inspection of the thrust plate alone.

Constant volume assured

The principle of automatic adjustment of end clearance by internal pump pressure had one main weakness. The full pump pressure was applied against the whole area of each thrust plate. The plates would wear unevenly because on the inlet side of the pump the plate had full pump pressure on one face and a vacuum on the gear side.

By "pressure pocketing" Commercial insured that the pressures on opposite faces of the thrust plates would be in approximate balance around the entire area of the plate faces. Commercial's "one-two" advance design punch—the patented "pressure pocketed" thrust plate—assures constant volume at any pressure and at the same time helps to maintain simplicity of design and soundness of construction . . . provides for longer operating life and no maintenance headaches.

Seizing eliminated

Commercial oil-hydraulic pumps cannot seize because of heat induced by high speed or even inadequately piped systems. Variable end clearance and positive internal alignment make seizing practically impossible. Bearings evenly loaded throughout their length—no corner loading or spawling—are able to withstand much higher operating pressures. They stay in service longer too—regardless of pressures involved.

To take full advantage of tight internal tolerances Commercial designs, produces and grinds its own rotating gears—is able to hold extra close tolerances on tooth contours, outside diameters, and concentricity.

Over 5,000 different pump combinations—port locations and sizes—can be built from Commercial's standard line of oil-hydraulic pump components. A wide variety of drive shafts and mounting combinations are available to solve virtually any individual installation, piping and power application requirement.

Engineering help available

Commercial's oil-hydraulic pump engineering advances are typical of its complete line of oil-hydraulic equipment. The solid technical help Commercial sales engineers can contribute on the application of oil-hydraulic pumps, motors, cylinders and valves may be able to help cut your costs and improve performance.

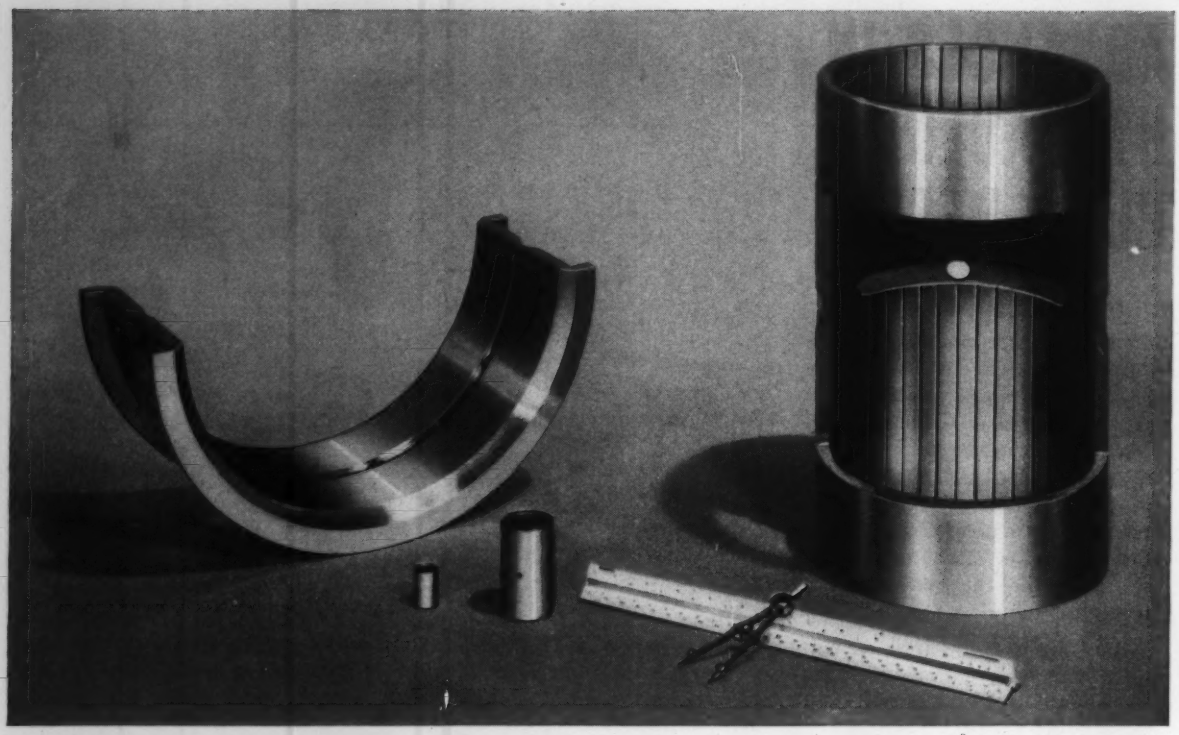
ENGINEERING DATA FREE

For more information write to Dept. S-38 Commercial Shearing and Stamping Company, Youngstown 1, Ohio. Better yet, send for your copies of Commercial's free engineering reference bulletins. Just check the items below in which you are interested.

- ☐ "Oil-Hydraulic Pumps and Motors Catalog H-4"
- ☐ "Performance Rated Oil-Hydraulic Valves Catalog H-12"
- ☐ "Oil-Hydraulic Cylinders Catalog H-3"

COMMERCIAL
shearing and stamping

Circle 566 on Page 19



Big or small, Johnson cast bronze bearings lick the tough jobs

BIG or small, Johnson Bearings, plain, grooved or designed for solid lubricants—up to 30-inch lengths—are precision-designed to give trouble-free performance, plus long life in demanding applications where heavy duty is a factor . . . or where . . .

- **it may be difficult to lubricate or lubrication may be neglected.**
- **high temperatures may rule out ordinary oils or greases.**
- **temperatures are too high or speeds are too slow to sustain an oil film.**

Available plain, with oil grooves, plug type or serrated type graphite, these tough Johnson bearings can be custom-made easily for rigorous applications. Serrated types are available from stock in more than 175 sizes; plain bearings in more than 900 stock sizes. For special applications *twenty-five* quality Johnson alloys are yours to choose from to assure the inherent quality of these bearings—plain or flanged.

To get the bearing you need for an economical investment, call, write or wire Johnson Bronze Co., 525 South Mill Street, New Castle, Pa. Do it today.

Johnson Bronze

525 South Mill Street • New Castle, Pa.

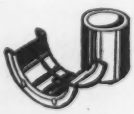
Subsidiary: Apex Bronze Co., Oakland, Cal.

JOHNSON Bearings

POWDER METALLURGY—BRONZE OR IRON

ALUMINUM ON STEEL SOLID ALUMINUM

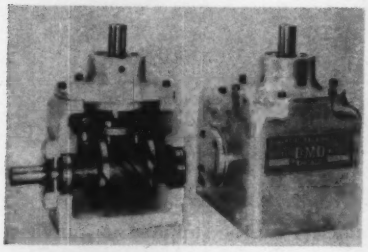
BRONZE ON STEEL



STEEL AND BABBITT

GRAPHITED BRONZE

BRONZE—CAST OR ROLLED



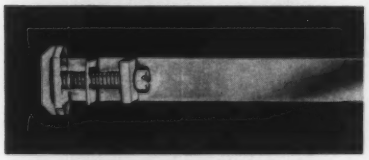
indexing periods of 270, 180, or 120 deg, with 3, 4, 6, 8, and 12 stops, left or right-hand cams. **Commercial Cam & Machine Co.**, 455 N. Artesian Ave., Chicago 12, Ill. J

Circle 768 on Page 19

Universal Hose Clamp

is adjustable, stainless-steel unit

Clamp fits any hose from 1 to 2 3/8 in. OD. Adjustable, stainless-steel unit consists of: stainless-steel band, 0.018 in. thick, 8 3/4 in. long, 1/2 in. wide; hardened, filister-head machine screw, nickel plated to resist rust; slotted nut, slotted section at right angles. Clamp is wrapped around hose, stainless-steel band is pulled through slot in nut, band is then bent over leg, and screw tightened. Clamp holds more than 150 lb internal pressure without leakage. It provides 360 deg clamping power



without damage to hose, and can be installed or removed without disconnecting hose. **Better Specialties Inc.**, 605 W. Washington Blvd., Chicago 6, Ill. J

Circle 769 on Page 19

Electrical Terminals

are easily inserted and fastened

Wrap-A-Wire terminals speed production of electrical and electronic assemblies, connectors for coil forms, and printed-circuit boards. Terminals are easily inserted and fastened, and single square lug prevents turning. Each terminal can take one or more wire leads using wire-wrap methods. Special plating or

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600 Sixteenth St., Oakland 12, Calif.

Circle 568 on Page 19

Stearns electro-magnetic miniature CLUTCHES

STYLE "SM"*

Now Available in 6 Standard Sizes

* Stationary Magnet

Installation-Proved Reliability . . .

Users' expressed satisfaction on the long life and maintenance-free operation of the thousands of SM's in use on their applications confirms the advantages of the heavy-duty design and construction features of these units.

Wide Range of Size and Torque . . .

Six Sizes (shown above) — 7/8, 1 1/8, 1 13/16, 2 1/8, 2 5/8, 4 1/4 in. square. Max. Torques Range from 25 oz in. to 240 lb in.

✓ Check—Compare these $aving Advantages:

1. Heavy-Duty Construction for long, trouble-free life. Heavy-gauge frame resists distortion. Solid-type, low-carbon "Armco" steel armature for greater strength and longer wear. Solid, molded, fully finished metallic and asbestos friction element for longer, efficient life than a thin cemented facing. All wear elements can be quickly, easily replaced, if required, at low cost.
2. Fast, Easy Installation . . . stationary field with flange-type mounting. Most sizes available with option of extended, ball-bearing-mounted driven hubs for integral sheave or pulley mounting.
3. Self-Adjusting.
4. No slip-rings or brushes to install or maintain. Furnished standard with 12-in. to 14-in. wire leads. Terminal block or plug-in connections are optional.
5. Moisture-, Corrosion-Resistant . . . coil is embedded in an epoxy resin compound—not merely coated. All metal parts finished with a chromate-converted zinc plating.
6. Fast, Positive Actuation.
7. Assures accurate, dependable, power or motion control energized by any adequate switching device.

For Superior Performance—Reliability . . . Specify Stearns!

Contact your local Stearns Representative for complete data and information on how to obtain prototype units for your specific installation. Or write direct, stating specific application information. Request Bulletin No. 504-BF.

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
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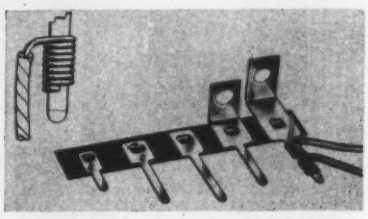

material can be supplied to individual specifications. Malco Mfg. Co., Dept. MD-1, 4025 W. Lake St., Chicago 24, Ill. I

Circle 770 on Page 19

Regulator Valve

operates from 0 to 300 psig

Pressure-control valve holds pressures in tanks to within 0.1-lb despite varying inlet pressures. Basic design can be adapted to a variety of sizes and pressure settings. It operates from 0 to 300 psig. Full flow is maintained within 0.2-lb above cracking pressure. Value functions efficiently in temperature range of − 65 to + 480 F. Almost any kind of gas or fluid can be regulated; with exotic gases and fluids, internal parts can be changed

with minor modifications to meet conditions. Unit weighs only 1 lb 7 oz. Besler Corp., 4053 Harlan St., Emeryville, Oakland 8, Calif. M

Circle 771 on Page 19

Conveyor Belting

in three or four-ply constructions

Low-cost, high-quality friction-surface conveyor belting, called Indestructible Slab, uses extra-thin skim coats of natural rubber to check wicking and block edge ravel. Use of high-grade rubber frictions makes belt harder to tear up or wear out. Fabric component is full-strength standard cotton duck which adds

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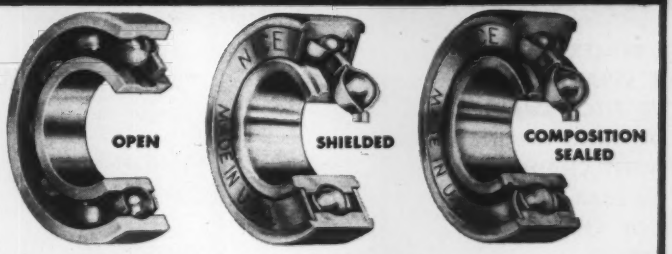
...for Good Reasons

- NICE offers complete lines of precision, semi-precision and unground standard bearings.
- NICE offers facilities and "know-how" to design and produce "specials" to exactly suit individual bearing application requirements.
- NICE standard and special bearings offer Product Designers many design improvement and cost-saving opportunities.
- NICE Bearings have proved their economic and performance value in the accepted products of many hundreds of well-known manufacturers.

CATALOG STANDARD BEARINGS

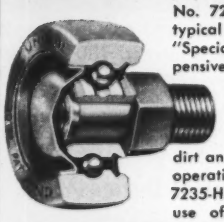


Typical "1600" Series Low Cost Precision Radial Bearings and "3000" Series Unground "Precision Type" Radials, Metal Shielded or Open, or with Composition Seals, Inch Sizes. Also "C" Series Precision Radial Bearings Metal Shielded or Open in established Light Duty Inch Standard Sizes. All Solid Inner and Outer Race Type with Retainer, as illustrated.

Another Typical Nice Catalog Standard, Inexpensive "500" Series Unground Radial and Thrust Bearings, Full Ball Type, Pressed Cone, Soft Outer Band, Inch Sizes.

Catalog Standard "600" Series "Steering Knuckle" type Self-contained Unground Thrust Bearings, Full Ball Type, Soft Outer Band, Inch Sizes.

SPECIAL BEARINGS



No. 7235-H Forage Harvester Cam Follower is typical of NICE experience and ingenuity as "Specialists in Specials". This relatively inexpensive one-piece assembly replaces a precision bearing with separate bolt and separate outer tire. A unique, but simple seal design* effectively retains lubricant and excludes dust, dirt and moisture under the difficult conditions of operation typical of farm implement service. No. 7235-H is also an example of the well applied use of the UNIBAL principle of construction.

The New UNIBAL® Ball Bearing

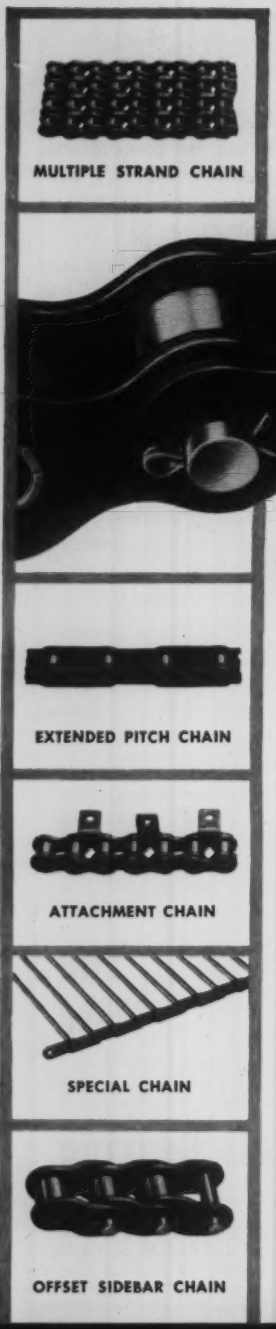
NICE now offers the revolutionary new UNIBAL, a low cost bearing of superior quality, suitable for many precision bearing applications. UNIBAL construction* features solid inner and outer raceways, with deep, unbroken ball grooves and a full complement of balls. Unique new manufacturing methods produce bearings of exceptional durability and strength.

Your Inquiries Invited.

NICE®

*Patent Applied For

NICE BALL BEARING COMPANY
NICETOWN · PHILADELPHIA · PENNSYLVANIA
DIVISION OF CHANNING CORPORATION



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lengthwise strength and resistance to side travel. Available in three or four-ply constructions, belting is bright orange. Nonstaining surface resists mild acids. Supple, natural-rubber construction allows belting to flex easily around small pulleys. Belting can be used for slider-bed service where it operates over hard wood or metal surfaces, or as a drive belt on live-roller conveyors. It is available in 14 stock widths from 4 to 48 in. and in 250 and 500-ft rolls. **United States Rubber Co.**, 1230 Avenue of the Americas, New York 20, N. Y. C

Circle 772 on Page 19

Pressure-Vacuum Controls

low-cost units are highly sensitive

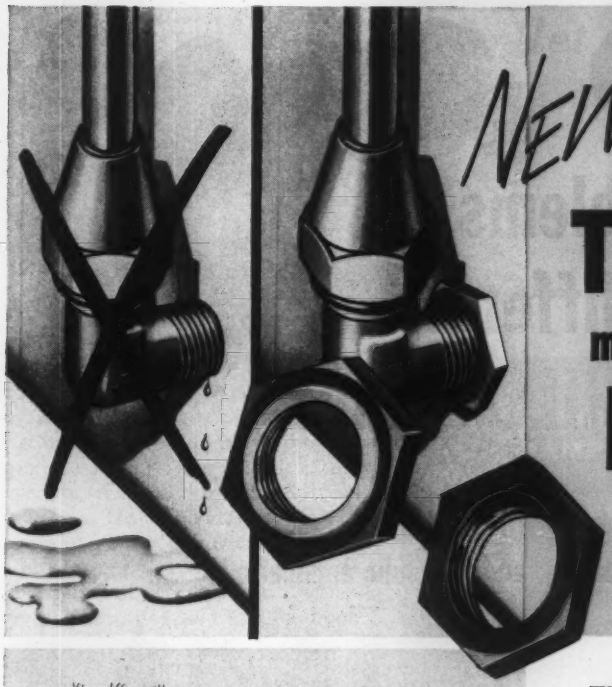
Designated Type J27 (uncalibrated) and Type H27 (calibrated), two pressure-vacuum controls are available in several models within range limits of 30 in. Hg vacuum, and 15 psi. Units meet need for a low-cost, highly sensitive instrument. Enclosure is die-cast aluminum with black wrinkle finish, and approximate weight is 2 lb. Many types of switches are available, and are rated 3 amp, 115/230 v ac. All switches are single pole and suitable for ambient temperatures to 180 F. **United Electric Controls Co.**, 85 School St., Watertown 72, Mass. B

Circle 773 on Page 19

Engine-Control Device

operates in speeds of 500 to 5000 rpm

Speed Monitor is a compact engine-control device which weighs 1 lb and has an accuracy of within ½ per cent of speed setting. Device is essentially a flyball-type governor containing flyweights resisted by cal-



NEW WEATHERHEAD TEF-SEAL® NUT

makes every pipe connection LEAKPROOF!

SAVE - expensive maintenance costs
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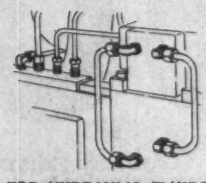
SAVE - valuable fluids



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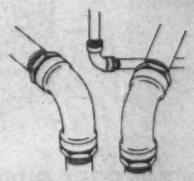
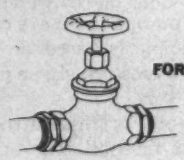


FOR ALL PROCESSING INDUSTRIES



FOR WATER

Eliminates leaks on all pipe threads—Dry Seal or standard. No pipe compound required. Quick, easy installations in cramped quarters where wrench clearance is limited.

Tef-Seal Nuts are an economical substitute for straight thread "O" ring boss fittings using original female pipe ports. Tef-Seal gives you positive seal on directional fittings like tees and elbows without distorting mounting bosses or damaging expensive valves and pumps.

NEW FORGED STEEL PIPE FITTINGS

Available in a wide range of sizes and styles, to meet most piping requirements.

Weatherhead steel pipe fittings are rugged, dependable for high pressure applications. They are precision machined from AISI 12L14 material to meet GMC dimensional standards. Weatherhead's exclusive ball-drilling process leaves no edges or sharp corners, eliminates turbulance and insures smooth, full flow. Corrosive resistant Weathercote finish is standard on these fittings, permits their use with all types of hydraulic fluids, water and air.

SPECIFICATIONS

Pressure Rated at 3,000 p.s.i. working pressure
Proof Tested: 15,000 p.s.i. in sizes up to 1¼"
10,000 p.s.i. in sizes 1½" and up
Each fitting is marked with its individual rating
All threads are American Standard Taper Pipe Threads — Dryseal (N.P.T.F.)

BRASS & STEEL FITTINGS • HOSE & ASSEMBLIES • TOOLS & ACCESSORIES

Write for your copy of our new General Industrial Catalog. Ask for Catalog C300.

THE WEATHERHEAD COMPANY • FORT WAYNE DIVISION
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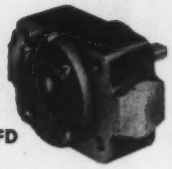
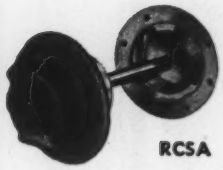
POWERMITE

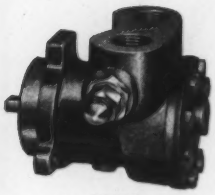
RCK


LFD


RCSA

For your pump problems . . . over 800 different TUTHILL pumps

SERIES 42


LPFV

- **Capacities to 200 GPM: pressures to 1500 PSI**
- **For lubrication, coolant, oil burning, circulating, and hydraulic applications**

For over 30 years the Tuthill Pump Company has been meeting the pump needs of American industry. In literally thousands of demanding applications . . . in lubrication, hydraulics, oil transfer and a wide variety of other services . . . Tuthill pumps are providing the dependable, trouble-free performance which has made them an industry standard.

With over 800 different models Tuthill provides a wide selection. Skilled application engineers, especially trained to "fit the pump to the problem", provide valuable design assistance in precisely meeting your pump requirements.

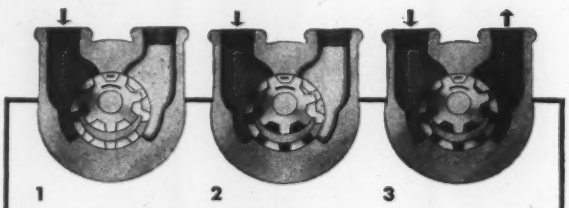
Most Tuthill units employ the time-tested internal gear operating principles described at the right. The complete Tuthill line also includes internal spur gear and sliding vane models.

Many options and modifications

Tuthill pumps can be furnished to fit the requirements of your particular application. For example they can be supplied:

- With or without built-in relief valve
- With automatic reversing feature where pump must be driven from a reversing shaft . . . or a machine must be shipped without knowing ultimate direction of driving unit
- As stripped models to be built into your equipment
- With a wide variety of porting arrangements
- With special shaft seals for various applications
- With provisions for steam jacketing
- With many shaft modifications for drive connections

In short, if your specifications lie within 200 GPM capacity, pressures to 1500 PSI, and speeds to 3600 RPM, Tuthill probably has the answer.



Internal gear pumping principle

In Tuthill internal gear pumps there are only two moving parts. The principle is based on the use of a rotor, idler gear and a crescent shape partition cast integral with the cover.

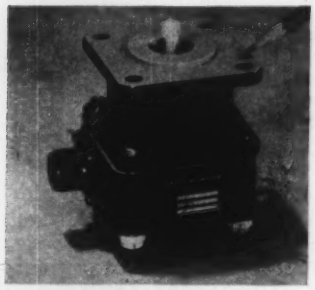
Power applied to the rotor is transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the outside diameter of the rotor is sealed by the crescent. As the pump starts the teeth come out of mesh increasing the volume. This creates a partial vacuum, drawing the liquid into the pump through the suction port (Fig. 1). The liquid fills the spaces between the teeth of the idler and the rotor and is carried past the crescent partition through the pressure side of the pump (Fig. 2). When the teeth mesh on the pressure side the liquid is forced from the spaces and out through the discharge port (Fig. 3).

Write today for catalogue 100. Or better yet, ask that a Tuthill Application Engineer call to discuss your specific pumping problem.

Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1 to 200 GPM; for pressures to 1500 PSI; speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois



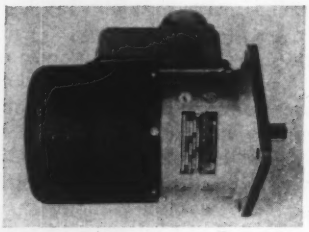
ibrated spring force. Instant response to engine rotation is obtained by extreme accuracy of calibration. Centrifugal force of flyweights becomes a thrust on an actuator that operates two snap-action electrical switches. Unit operates in a speed range of 500 to 5000 rpm at temperatures of −65 to +250 F with life expectancy of over 2000 hr. Permanently lubricated and ignitionproof, it is unaffected by altitude, attitude, sand, dust, or fungus. Unit meets requirements of MIL-E-5009A. **AC Spark Plug Div., General Motors Corp.**, Milwaukee 1, Wis. K

Circle 774 on Page 19

Reversible Motor

has speed of 10,500 rpm

Model 49EC1 compound-wound reversible motor is a 26-v dc, 1¾-hp unit designed for actuator service. Motor, with a speed of 10,500 rpm, is equipped with a brake with static torque of 500 oz-in. Unit meets requirements of MIL-M-



H609A. It measures 7 in. long x 4 in. diam. **Electro Products Div., Western Gear Corp.**, 132 W. Colorado Blvd., Pasadena, Calif. L

Circle 775 on Page 19

Linear Potentiometer

operates at temperatures from − 65 to +500 F

Linear-motion potentiometer gives precision electrical indication of me-

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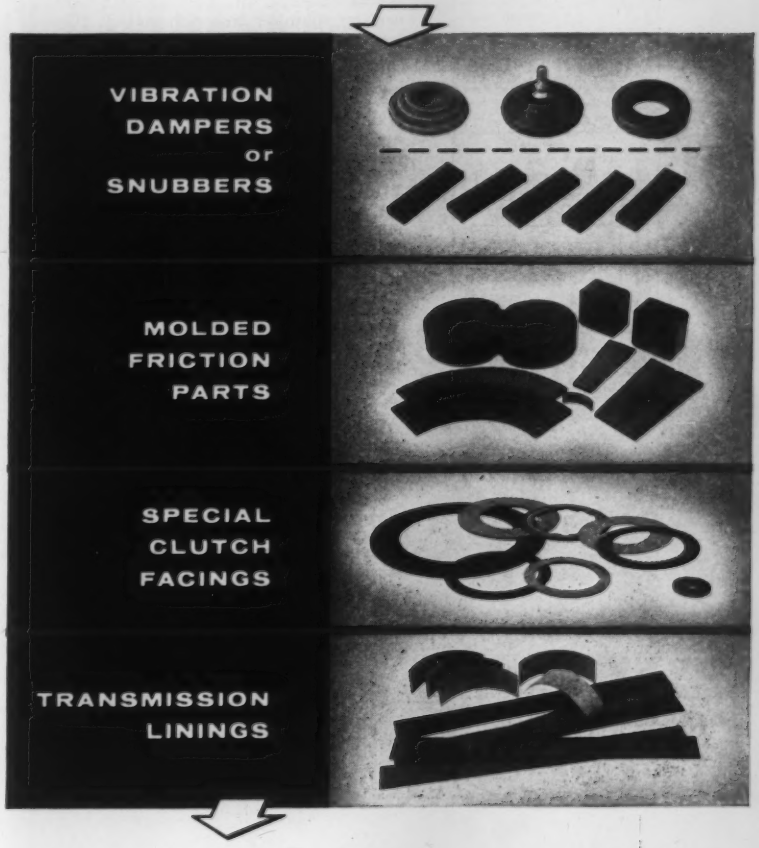
in the design and production of



● World Bestos offers you more than 30 years' engineering and manufacturing experience in the producion of molded friction parts. Chances are our immense resources and facilities can supply you with molded parts and friction components—to meet your requirements—at a savings in both time and money.

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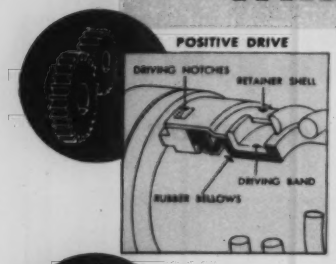
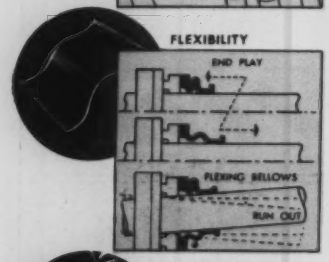
Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Special Clutch Facings • Vibration Controls • Sheet Packing

Circle 574 on Page 19

JOHN CRANE Shaft Seal Design With A Purpose!





POSITIVE DRIVE

This gives long seal life. Drive is transmitted through the driving band and washer driving notch which absorb all breakout and running torque. Damaging stresses on the bellows or flexible sealing member are eliminated. Slippage is also eliminated, thus protecting shaft or sleeve against galling.

FLEXIBILITY

Axial and radial misalignment problems are eliminated. Self-adjusting bellows or sealing head automatically compensates for shaft end play or run out. Minimum spring pressure is required for axial shaft movement and uniform spring pressure is maintained during radial shaft movement.

PRECISION MANUFACTURE

Leakproof performance is assured. Washer and seat surfaces are precision lapped to a perfect mate under a patented "John Crane" process.

A SEAL FOR EVERY SERVICE

All "John Crane" Seals are constructed to the particular service requirements . . . from hot or cold water to the most destructive acids, corrosives and gases . . . temperatures up to 1000°F. . . . pressures to 1200 psi. They can be furnished in types and sizes to meet practically any mechanical or dimensional condition.

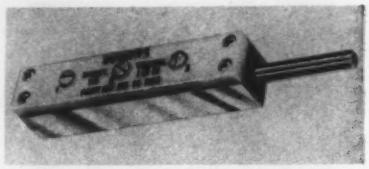
Request Bulletin S-204-2. Containing full information on "John Crane" engineered shaft seals.

GET COMPLETE DETAILS

Crane Packing Co., 6425 Oakton Street, Morton Grove, Ill. (Chicago Suburb)

In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

CRANE PACKING COMPANY



chanical position when used with hydraulic actuators, pneumatic valves, and linkage components. Designated Model 113, it operates at temperatures from −65 to +500 F. Instrument operates with high-level ac or dc signal, requiring no amplification for use in recording, control, and telemetering circuits. Metal-to-metal bond in resistance-element termination provides high resistance to thermal or mechanical stress. Unit is ½ x ⅝ x 2½ in. in size and has travel range of zero to 1.31 in. Power rating is 4 w at 40 C. Available resistances are 1000, 2000, 5000, 10,000, and 20,000 ohms. Unit meets or exceeds most government specifications. **Bourns Inc.**, P. O. Box 2112, Riverside, Calif. L

Circle 776 on Page 19

Instrument Oil

has temperature range of −75 to +350 F

Synthetic instrument oil, Anderol L-281, is a medium-viscosity diester oil developed specifically for use in precision instruments. Physical characteristics include extremely low evaporation rate, wide temperature range (−75 to +350 F), compatibility with ordinary lubricants, and excellent penetration. Lubricant has excellent oxidation stability, is nongumming, and will not leave harmful deposits. Applications include clocks and watches, precision bearings, pneumatic systems, hydraulic systems, electrical control boxes, electric motors, parking meters, and all types of instruments and timers. **Industrial Lubricants Div., Lehigh Chemical Co.**, Flatland Road, Chestertown, Md. C

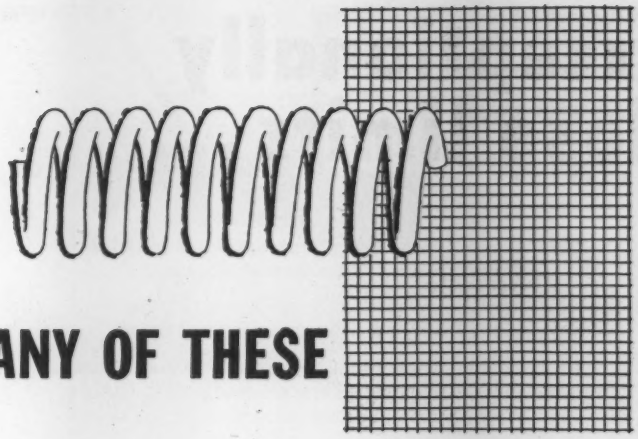
Circle 777 on Page 19

Spray Nozzle

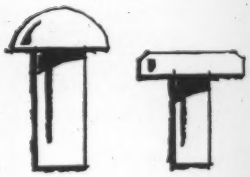
sprays liquids containing mildly abrasive particles

WhirlJet spray nozzle produces a hollow-cone spray pattern with uniform distribution and uniform circu-

Circle 575 on Page 19

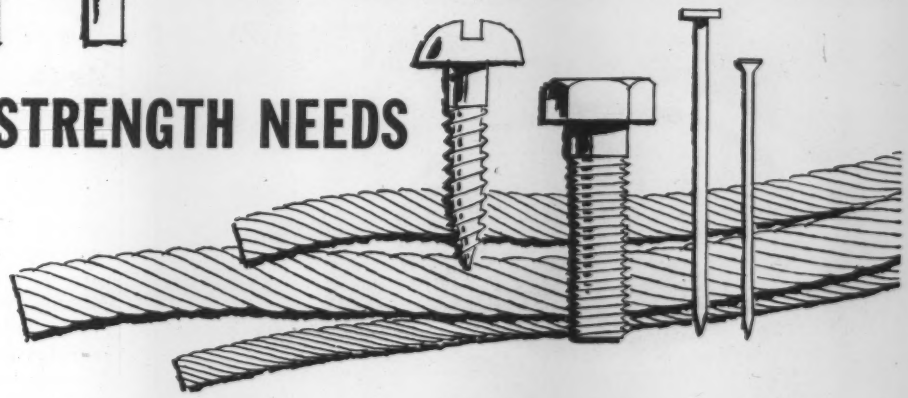


IF YOU MAKE ANY OF THESE



FOR CORROSION RESISTANCE

AND HIGH STRENGTH NEEDS



See what Allegheny Stainless steel wire can do to cut your costs

The assurance of uniform quality, order after order, shows up in lower shop costs in whatever you make from stainless steel wire. A-L specifications are faithful in every batch—in all grades of stainless steel cold-drawn wire, tempered to match many correlations of hardness and tensile strength.

If you make springs, you get uniform tensile strength in every batch of spring wire . . . and also with rope wire.

In weaving wire you get the same dead-soft temper and uniform properties for perfect weaving without ridges.

In cold-headed wire you get absolute uniformity that ties in with automation production processes.

Call on the A-L technical staff for help with selection or fabrication problems, or help in cutting shop costs in processing operations. They will be glad to work with you.

Whatever you make in stainless wire, Allegheny Ludlum offers you adequate stocks of all standard grades for fast shipment. Special stainless steel wire on order.

Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. MD-21.

Write for your copy of Allegheny Stainless Wire, Illustrated 20-page booklet, which fully describes analyses, physical properties, corrosion resistance and principal applications of stainless wire.

WSW 7999

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EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

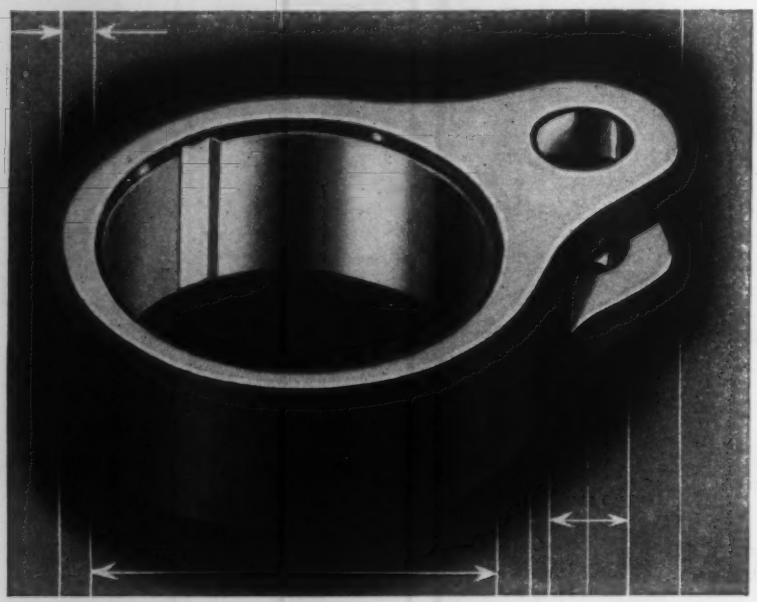
exceptionally close limits...

The photograph shows the connecting rod of an unusual hydraulic pump built by a company whose name is known everywhere.

The finish in the bore of both the large hole and the small hole must be held to very fine profilometer reading.

In addition, the axes of these two holes must be parallel to each other within exceptionally close limits. Naturally, the user of a cast bronze part such as this turns to Bunting in order to assure strictest adherence to his print and specifications.

For the unusual, as well as the usual, in bearings, bushings, bars, or special parts of cast bronze, sintered bronze, or Alcoa aluminum, try Bunting first.



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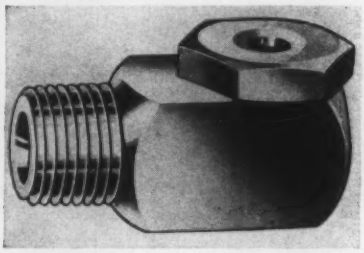


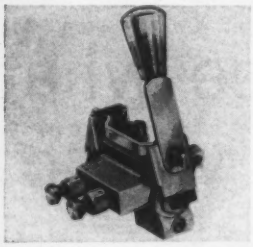
lar shape. It is intended for applications where liquids containing mildly abrasive particles are sprayed. Type AX and BX nozzles are supplied in brass, steel, and 303 stainless steel. Range of capacities is offered in 1/8, 1/4, and 3/8-in. female or male pipe-connection sizes. **Spraying Systems Co.**, 3274 Randolph St., Bellwood, Ill. J

Circle 778 on Page 19

Air-Control Valve

has built-in speed controls

Four-way air-control valve features speed of operation and self-contained speed controls which allow easy adjustment of both forward and reverse cylinder stroke. Operating on the bleed principle, the valve shifts with release of only a small volume of air. Short-stroke



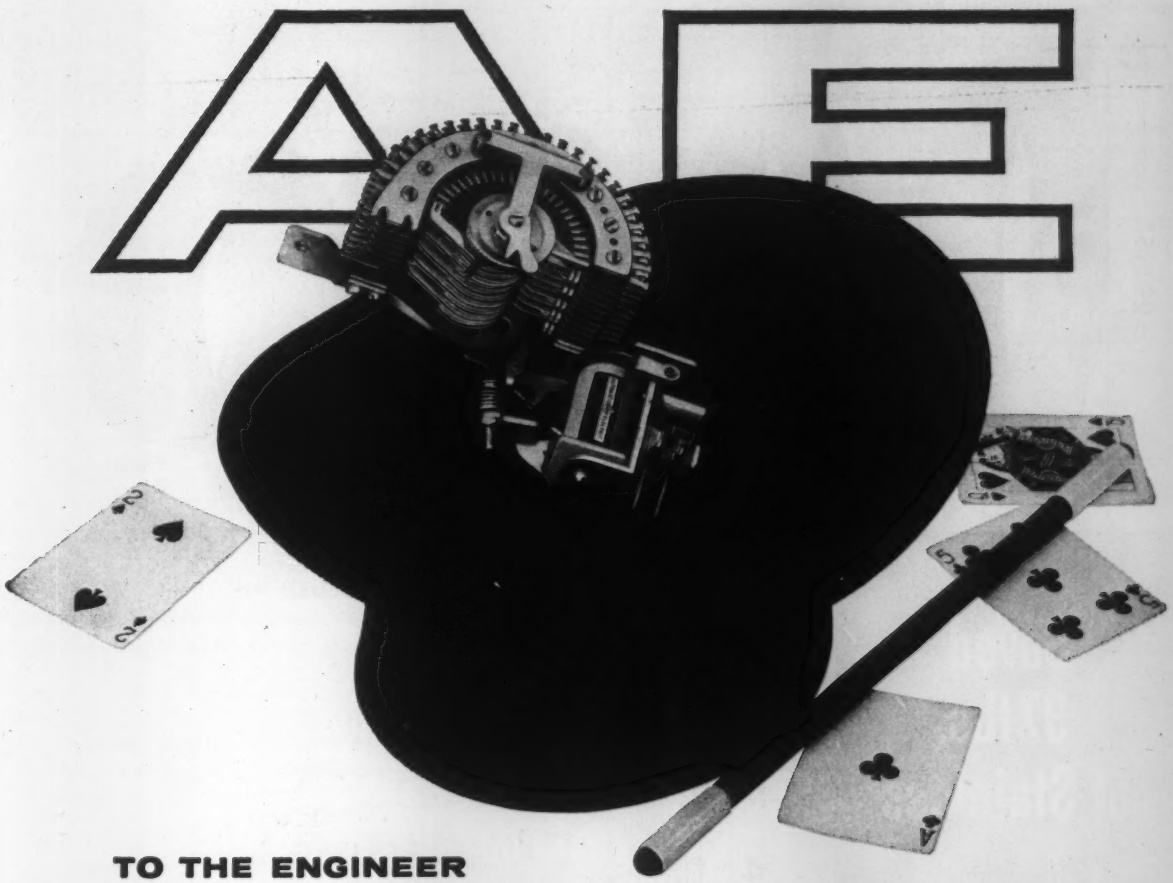
sleeve and valve insert assure rapid response and flow change. Valve operates on pressures as low as 1 psi. **Cleveland Pneumatic Industries**, 64 Old Orchard, Skokie, Ill. J

Circle 779 on Page 19

Dual Connectors

for use with binding posts

Multipurpose Dub-L-Plug dual connectors provide quick, safe electrical connections to binding posts mounted on 3/4-in. centers. Available shielded or unshielded, they feature gold-plated conducting metal parts,



TO THE ENGINEER

who can use a little honest trickery

There's more than one way of skinning a cat —or making ideas *work* automatically. And AE has a bag-full.

That's because AE has had years of experience in making relays and stepping switches work wonders in automatic telephone exchanges—*and* in automatic control devices.

If you can use some down-to-earth magic in your designs, AE engineers will be glad to help. And you may well find that their suggestions can simplify the control package.

They can also show you why AE relays and stepping switches cost you less in the long run.

For instance, the AE Type 45 Stepping Switch, illustrated, has a free-floating pawl that never binds, never breaks, eliminates the necessity of ever readjusting armature stroke, does away with double-stepping or overthrow. And the switch usually outlasts the equipment it's built into!

You'll also be interested in knowing that AE is equipped to deliver completely wired and assembled control units designed to your specifications.

Want more information? Just write the Director, Industrial Products Engineering, Automatic Electric, Northlake, Illinois. Ask for Circular 1698-H: *Rotary Stepping Switches;* Circular 1702-E: *Relays for Industry;* and our new 32-page booklet on *Basic Circuits.*

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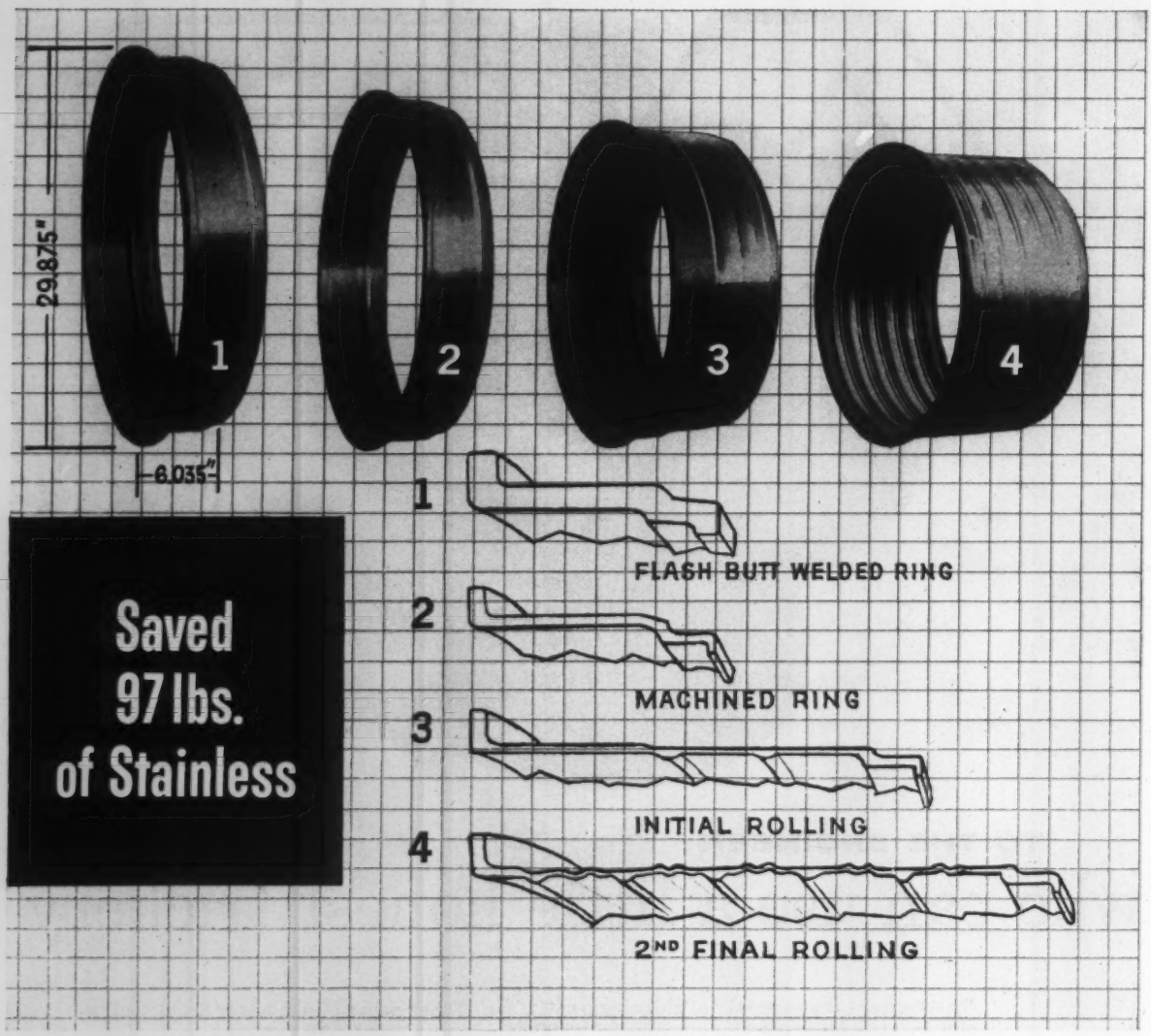

Jet Compressor Case is Rotary Roll-Formed From Flash Butt-Welded Rings--Excess Material Eliminated

Have you looked into the cost saving possibilities of using flash butt-welded rings for rolling or spinning operations? Where Amweld rings have been substituted for heavy forged blanks, users report excellent rolling performance and finished parts met all specifications. Cost per part was reduced $25.40 each.

Amweld flash butt-welded rings can help you cut fabricating costs. Write or call today. Better yet, mail us your prints and specifications. We will study your problem and work with you.

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Complete information. Facilities brochure, Precision Assemblies Catalog, and booklet on "How Flash Butt-Welded Rings are Made."

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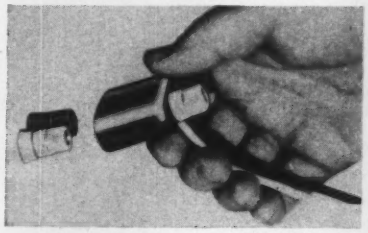
AMERICAN WELDING

color-coded captive thumbnuts, and recessed twin banana plugs. Shielded insulated model has die - cast, chrome-plated metal case and internal-grounding banana plug that can be removed when using on two-wire ungrounded circuits or with two - conductor shielded cable. Shielded cable can be grounded to case with nylon cord-locking screw. Insulated connectors, used where



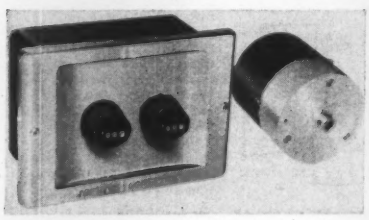
shielding is not necessary, have nylon-plastic bodies available in four colors, white, and black. They provide for wiring connection by stud-hole clamping, looping and clamping, or by spade lug, clip lead, or banana plug. Wiring slots permit stacking if desired. **Superior Electric Co.**, Dept. DLP, Bristol, Conn. B

Circle 780 on Page 19

Electric Limit Switch

permits fast setting of trip or set points

Electric limit switch senses and remotely limits position, weight, level, or pressure. It is for applications where one or more trip points must be reset frequently, as in sequencing and programming. Limits are set quickly to accuracies of 0.2 per cent of full scale for standard units or to one part in 250,000 for high-accuracy systems. System consists of two components—setter and sensor. One or more limit points are set in on individual dials or counters of setter (left). Each dial sets a precision potentiometer or resistor which serves in one leg of



4 solutions to your special timing applications...

HANSEN SYNCHRON TIMING MOTORS

• **Versatile Hansen SYNCHRON Timing Motors** have *proved* more dependable in meeting impartial test requirements than competing motors. Such tests prove that Hansen SYNCHRON motors deliver peak operating efficiency continuously for as much as 1½ years, and longer.

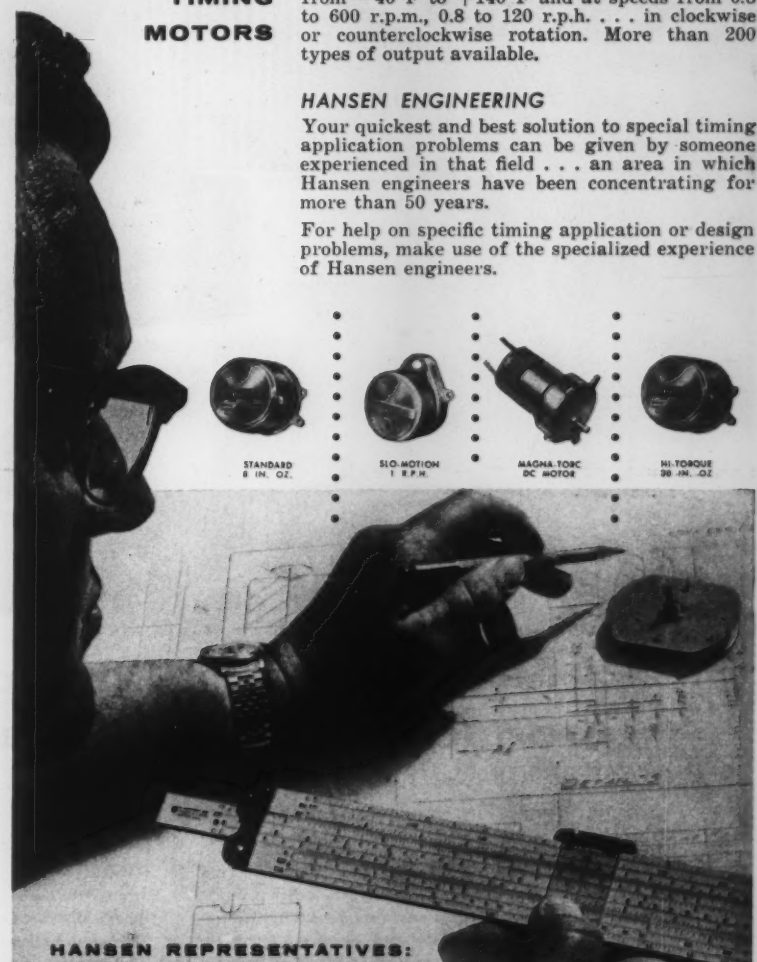
Each of the 4 Hansen SYNCHRON Timing Motors shown here gives this kind of performance . . . and one could be the solution to your timing problem. Some of the wide variety of commercial and industrial applications include: timing machines; telemetering and transmission equipment; cam and valve switches; heating and air conditioning devices; recording thermometers; television cameras and equipment; and many others.

Self-starting and self-lubricating, these Hansen SYNCHRON Timing Motors operate efficiently in any position. They pull from 8 to 30 in./oz. guaranteed torque . . . at temperatures ranging from —40°F to +140°F and at speeds from 0.8 to 600 r.p.m., 0.8 to 120 r.p.h. . . . in clockwise or counterclockwise rotation. More than 200 types of output available.

HANSEN ENGINEERING

Your quickest and best solution to special timing application problems can be given by someone experienced in that field . . . an area in which Hansen engineers have been concentrating for more than 50 years.

For help on specific timing application or design problems, make use of the specialized experience of Hansen engineers.



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Circle 580 on Page 19

"Here's a boxful of cost-cutting, product-improving ideas for you"

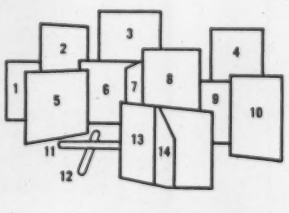
In versatility, performance and cost, Vulcanized Fibre may help crack your next design problem

For proof, look at this National product and its almost unbelievable range of uses. To name a few: delicate surgical instruments; rail joint insulation for railroads; clothes hampers for the home; dense, durable gears and cams; flexible backings for abrasive disks; arc chutes for lightning arrestors; motor insulation; punched tape for data processing machines; formed athletic guard equipment.

Among engineering materials you'll find National Vulcanized Fibre unique and surprisingly economical. It weighs only half as much as aluminum. It has unsurpassed arc resistance, low thermal conductivity, excellent resilience and high abrasion resistance. It absorbs sudden and repeated shock and impact without failure. And it is available in a fire resistant grade.

After 100 years, users are still finding new things they can do *to* Vulcanized Fibre. It can be machined, polished, painted, embossed, lacquered and combined with other materials, such as laminated plastic, aluminum, wood, rubber, asbestos or copper. It can even be formed or deep drawn into intricate shapes. Available in both standard and special forms and sizes.

Send for our special kit of samples (shown above)—write on your letterhead please—and evaluate the design possibilities personally. Let us know what use you have in mind. We'd like to help. National Vulcanized Fibre Co., Dept. G-9, Wilmington 99, Delaware.



1. "Peerless" Electrical Insulation. 2. Embossed, vinyl finish. 3. Corrugated "Peerless" .010. 4. Fibre and "Mylar." 5. Cold embossed. 6. Fibre-Copper, two-sides copper. 7. Black Commercial. 8. Fibre-Laminated Plastic, two-sides fibre. 9. Red Commercial. 10. Corrugated. 11. Rod. 12. Tube. 13. White. 14. Fibre Armored Plywood.

Circle 581 on Page 19

CHOOSE FROM THESE MATERIALS...

Vulcanized Fibre: 10 standard grades; many special grades.

PHENOLITE® Laminated Plastic: over 80 standard and modified grades; paper, cotton fabric, nylon, asbestos, glass fabric, cotton and glass mat bases; phenolic, melamine, polyester, epoxy, teflon or silicone resins.

PEERLESS Electrical Insulation: coil, strip, corrugated.

Extruded Nylon: 2 grades; rod, strip, pressure tubing, special shapes.

Polyester Glass Mat: 4 standard sheet grades; custom molded shapes.

PHENOLITE Copper-Clad Laminates: 10 standard grades.

Combination Materials: Rubber-PHENOLITE; Rubber-Fibre; Wood-Fibre; Metal-Fibre; Asbestos-Fibre; PEERLESS-PHENOLITE.

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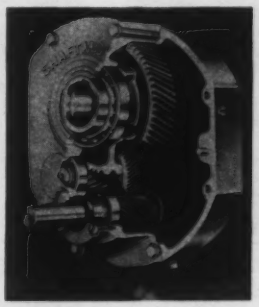
bridge circuit. Sensor varies a resistance in other leg of bridge circuit. Sensor is usually a matching potentiometer, but can be any resistance-varying transducer. Frequently employed sensor is shaft-mounted unit (right) which includes built-in potentiometer and choice of gear trains so that full-scale control can be obtained for any number of turns of shaft on which sensor is mounted. **Jordan Co. Inc.**, 3235 W. Hampton Ave., Milwaukee 9, Wis. K

Circle 781 on Page 19

Speed Reducer

for direct mounting on driven shaft

Shaftmount Syncrogear, Type GC, is available in a range of sizes from 1/4 to 40 hp, speeds from 125 to 5 rpm, and 15:1 or 24:1 ratios. Wide choice of mounting positions makes unit adaptable in limited-



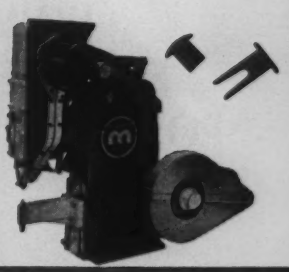
space applications. Where application requires reverse protection, a positive, nonreverse backstop is available. Located on front of unit, it permits quick, easy installation without dismounting unit from shaft, and is easily removed and reversed when gear rotation in opposite direction is desired. **U. S. Electrical Motors Inc.**, Box 2058, Terminal Annex, Los Angeles 54, Calif. L

Circle 782 on Page 19

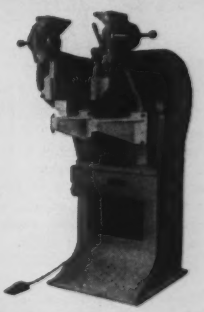
Silicon Rectifiers

are rated at forward current of 25 amp

Fourteen silicon stud-mount, medium-current rectifiers are available in seven conventional types, with stud as cathode, and seven reverse-current types, with stud as anode.



CUT RIVET ASSEMBLY COSTS



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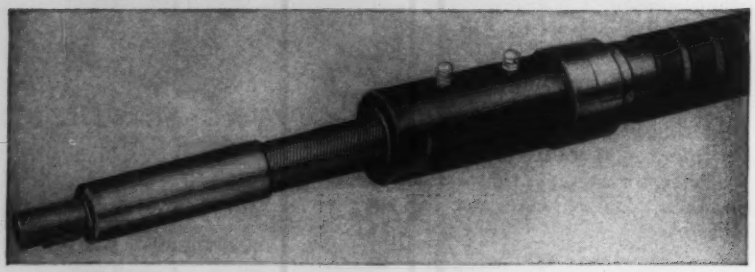
Circle 582 on Page 19

HOW TO SELECT FLEXIBLE SHAFTING FOR POWER DRIVE APPLICATIONS



1¼-inch STOW Power Drive flexible shaft with core assembly pulled out of casing.

For Power Drive applications, the following factors must be considered:

1. Torque (Lb. In.) to be transmitted. (The starting torque should be used in making selections.)

2. Operating Speeds (RPM) — If the maximum speed is higher than the rated speed, torque ratings in the table below do not apply. To find the torque capacity for flexible shafts operating at speeds higher than the rated speeds, multiply the maximum dynamic torque capacity by the rated speed, and then divide by the operating speed. (See example).

3. Operating Radius—in making the selection from the table below, the radius of the smallest bend in the flexible shaft should us used.

Ratings — The ratings for flexible shafts shown in the table below apply under the following conditions:

1. When the flexible shaft is adequately supported by clamps along its length. (For unsupported shafts, multiply the calculated torque by a safety factor of 1.6—see example below.)
2. When the flexible shaft is operated in the wind-up direction, which tends to tighten the outer layer of wires. (Flexible shafts operated in the unwind direction will transmit only about 60% of the rated torque.)
3. When the flexible shaft is in continuous operation. Note: **the ratings are based on temperature rise. When the operation is intermittent, the ratings in the table may be exceeded. Consult Stow engineers for specific recommendations.**

RATED SPEED R.P.M.	MAXIMUM DYNAMIC TORQUE CAPACITY (LB. IN.) STRAIGHT AND CURVED SHAFTS RADIUS OF CURVATURE IN INCHES									Wgt./ C. Ft.	Core Dia.	Core No. and Type	Shaft Size
	50 to Strgt.	25	20	15	12	10	8	6	5				
4,500	2.4	2.2	2.0	2.0	1.92	1.9	1.7	1.5	1.25	3.0	.124/.128	2049 MH	13
3,800	7.0	6.4	6.0	5.8	5.4	5.0	4.6	3.6	2.0	4.5	.148/.152	2081 MH	15
2,900	9.4	8.6	8.0	7.6	7.0	6.6	6.0	4.8	3.4	7.0	.185/.189	5108 MH	19
2,500	22.0	20.0	18.8	17.6	16.0	15.0	12.6	10.8	9.0	12.5	.247/.252	8924 MH	25
1,800	30.0	28.0	26.4	25.0	23.0	21.0	18.0	14.0		20.0	.308/.313	8925 MH	31
1,800	33.8	31.5	29.7	28.1	25.9	23.6	20.2	15.8		20.0	.308/.313	8969 T	31
1,800	36.0	33.0	31.6	30.0	28.0	26.0	22.0	18.0	11.0	21.0	.324/.329	2034 A	31
1,500	80.0	66.0	63.0	58.0	51.0	46.0	37.0	22.0		28.5	.368/.374	2035 A	38
1,500	60.0	54.0	50.0	46.0	42.0	38.0	30.0	24.0		29.0	.387/.393	8970 MH	40
1,500	90.0	81.0	75.0	69.0	63.0	57.0	45.0	36.0		29.0	.387/.393	8971 T	40
1,150	136.0	110.0	104.0	94.0	80.0	72.0	56.0			50.5	.497/.503	8999 A	50
1,150	148	124	110	92	72	56				53.5	.505/.511	6940 T	50
900	248	200	176	124	84					78.5	.610/.618	6997 T	63
900	220	204	192	180	152	130				80.5	.630/.638	7731 A	63
750	340	224	156	76						117	.747/.753	2056 T	75
600	760	520	420							205	.998/1.004	2057 T	100
440	1,500	720								343	1.298/1.304	2058 T	125

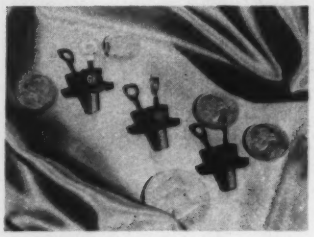
EXAMPLE—How to use the table:

The problem is to transmit ½ H P at 1700 RPM through an unsupported flexible shaft in a 25" radius, estimated starting torque 150% of normal operating torque.

1. Calc. Torque (lb. in.)—
$$\frac{HP \times 63000}{RPM} = \frac{.5 \times 63000}{1700} = 18.5$$
2. Correction factor for starting torque 1.5 x 18.5 = 27.75
3. Correction factor for unsupported shaft 27.75 x 1.6 = 44.4 lb. in.
4. Refer to Table above. Read downward in column under 25" radius until you find a core having a rating of at least 44.4 lb. in. In this case we find that core no. 8970 is rated 54 lb. in. at 1500 RPM. Since the given speed is 1700 RPM, multiply 54 by 1500 and divide by 1700. 54 × 1500 ÷ 1700 = 47.6 lb. in. (rated torque at 1700 RPM). Therefore, Core No. 8970 is correct.

STOW

For Engineering Bulletin No. 570 and a free torque calculator, write
STOW MANUFACTURING COMPANY
11 Shear Street • Binghamton, New York



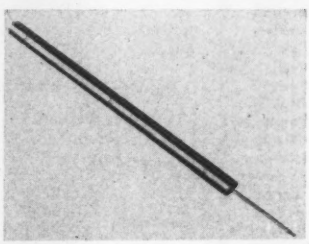
Rectifiers have peak inverse-voltage ratings from 50 through 600 v. All units are rated at forward current of 25 amp in single-phase circuit at stud temperature of 145 C. Maximum one-cycle surge current rating is 300 amp. Maximum leakage current at full load is 5 ma for 50-v units down to 2 ma for 600-v units in single-phase circuit at stud temperature of 145 C. Rectifiers conform to EIA outline DO-5 and use 11/16-in. hex. **Semiconductor Products Dept., General Electric Co.,** Liverpool, N. Y. N

Circle 783 on Page 19

Rectilinear Potentiometers

have strokes from 2½ to 10 in.

Cylindrical rectilinear potentiometers with ¾ in. diameter are available with single or dual elements and strokes ranging from 2½ to 10 in. All units display shock, acceleration, and vibration resistance in excess of 50 g without opening or discontinuity. Other outstanding



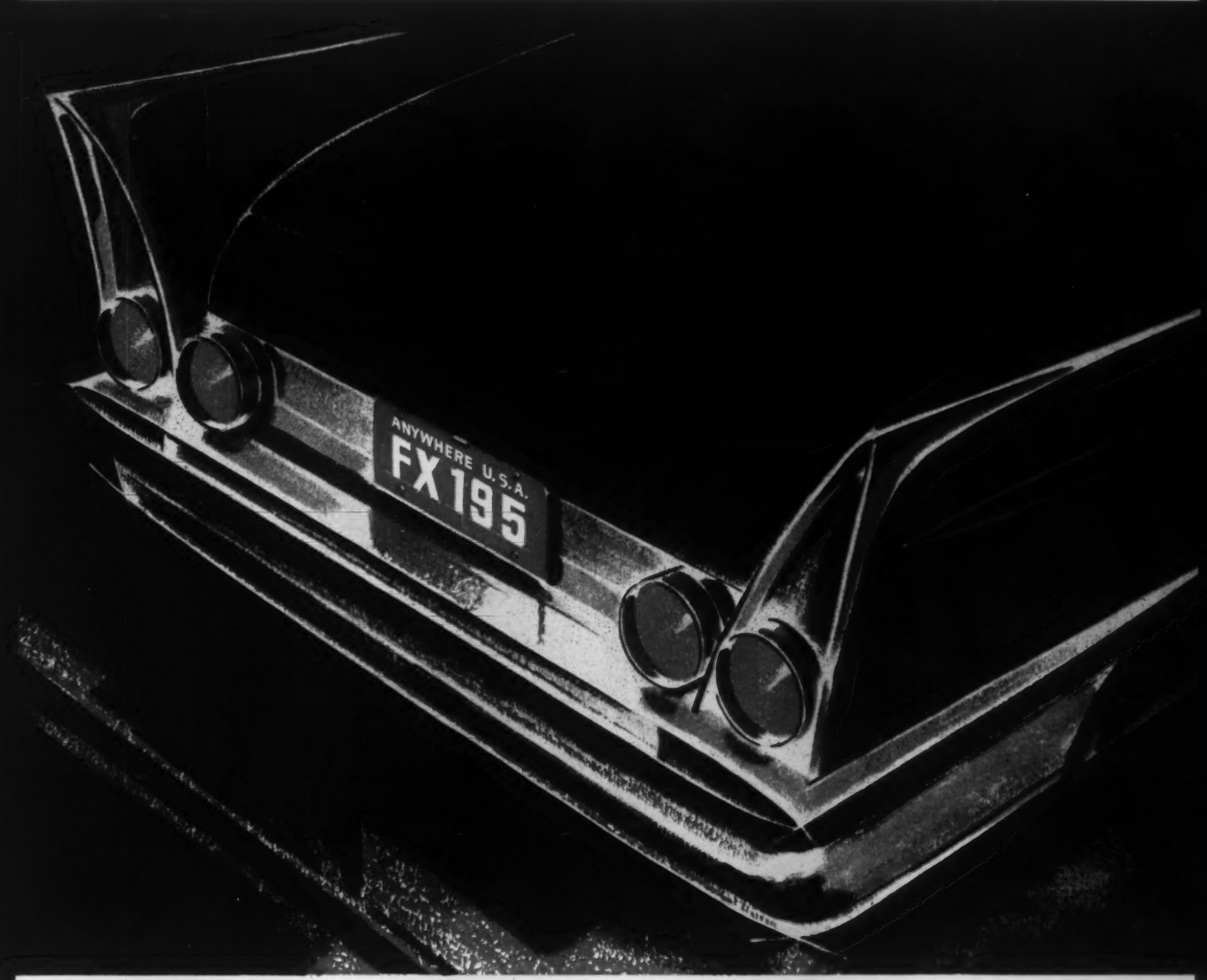
characteristics are virtually infinite resolution and independent linearity in the order of ±0.2 per cent. **Markite Products Corp.,** 155 Waverly Place, New York 14, N. Y. D

Circle 784 on Page 19

Metering Pump

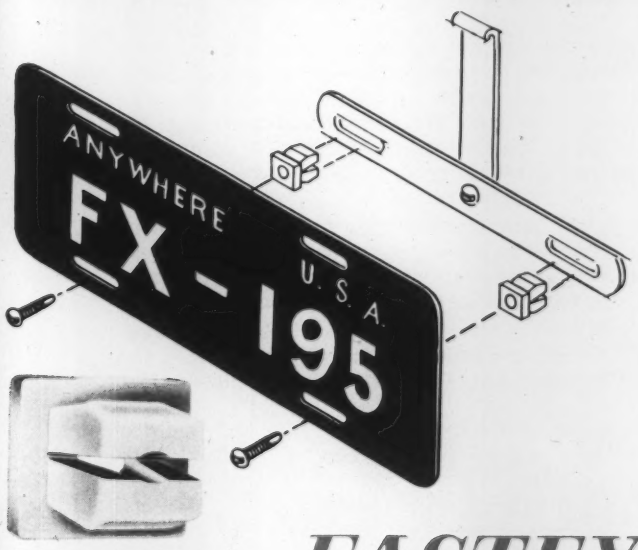
has maximum flow of 2.5 gal

Diaphragm pump is designed for positive-displacement metering of a range of corrosive and noncorrosive



Tough fastening problem... simple answer:

FASTEX® PLASTI-GROMMETS®

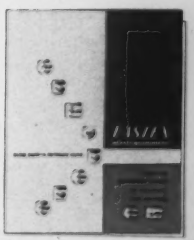


Using Fastex Plasti-Grommets to mount license plates demonstrates their use in blind applications, just one of their unique solutions to fastening problems. They are also ideal for any application requiring rugged fastening strength, electrical or thermal insulation, corrosion-resistance and ease of assembly. They snap into place easily and lock tight when the screw is driven.

Fastex Plasti-Grommets have been specified by leading manufacturers for years. Typical of the many mass-production industries they serve are television, where they are used as electrical insulation fasteners, and in manufacturing refrigerators where they serve as thermal insulation spacers.

SEND FOR NEW CATALOG FEATURING STANDARD PLASTI-GROMMETS!

Fastex Standard Plasti-Grommets can mean big cost-savings! This new catalog contains handy ordering information and idea-suggesting case studies. See where Plasti-Grommets can cut your costs!



Circle 584 on Page 19

FASTEX

A DIVISION OF ILLINOIS TOOL WORKS
195 Algonquin Road, Des Plaines, Illinois
In Canada: SHAKEPROOF/FASTEX
Division of Canada Illinois Tools Ltd., Don Mills, Ontario

itw

LGP-30

ROYAL PRECISION

Here is the low-cost, desk-side electronic digital computer you need for general design and system optimization

Speeds optimum design of new products and equipment!

Operating from any convenient wall outlet, the compact, powerful LGP-30 will today furnish you with high-speed electronic computation wherever you need it . . . will eliminate tedious hand calculations . . . help you free up more creative time.

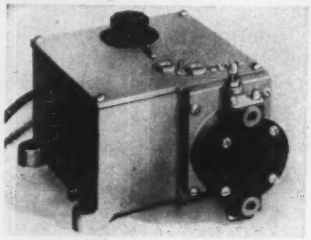
Combining large memory (4096 words) and stored-program operation, the LGP-30 gives you twice the capacity of any computer in its class, yet is by far the easiest to program in basic machine language. Simplified controls can be operated with only minimum computer experience. Answers are printed out directly—require no deciphering. Best of all, even with these many unique advantages, the LGP-30 is the lowest-priced complete computer you can buy. What's more, auxiliary high-speed input—output equipment is available for system expansion.

No expensive installation or air-conditioning required. Customer training is free. An extensive library of programs and sub-routines is available—as well as membership in an active users organization. Sales and service facilities are maintained coast-to-coast.

For further information and specifications, write Royal McBee Corporation, Data Processing Division, Port Chester, N. Y. In Canada: The McBee Company, Ltd., 179 Bartley Drive, Toronto 16.

ROYAL McBEE · *data processing division*

liquids. Pump satisfies requirements of high accuracy and low-flow metering with four flow ranges available to maximum of 2.5 gph. Hydraulically balanced Teflon diaphragm eliminates flexing fatigue and distortion of flow rate. Unit operates against back pressures as high as 500 psi. Wetted parts can be constructed of many materials such as plastic, stainless steel, and



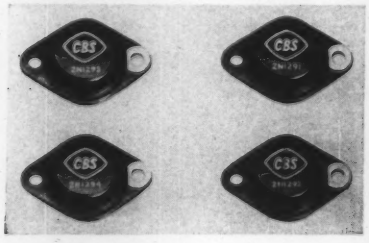
nickel. Operating mechanism is totally enclosed and completely submerged in oil. Pump is available in multihead construction and for automatic proportioning from pneumatic or electric-impulse signal. **Pump Div., Clark-Cooper Co.,** 315 Market St., Palmyra, N. J. D

Circle 785 on Page 19

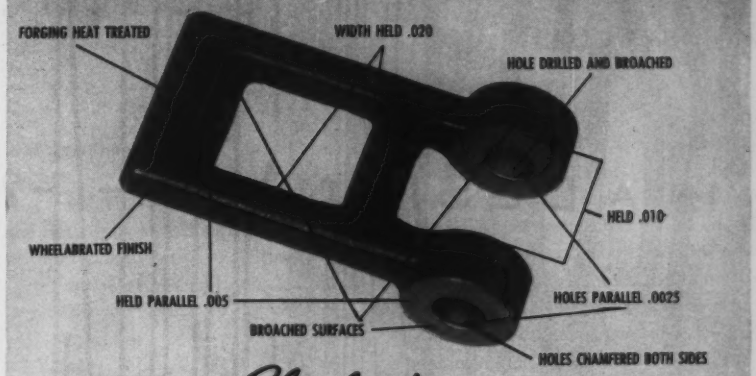
Power Transistors

are complementary NPN-PNP units

Five complementary pairs of NPN-PNP transistors in diamond package permit circuit-design economies. They eliminate input and output transformers in push-pull circuits to save money and space, and also provide improved frequency response. Negative feedback can be more easily applied using the transistors. NPN transistors have electrical characteristics identical to those of PNP counterparts. Pairs feature voltages up to 100 v, and reliability exceeding MIL-T-19500A for audio, control, voltage - regulation, servo, and computer applications. All types have maximum collector cur-



PRINT-TO-PRODUCT SERVICE



FORGINGS BY *Cleveland*

How many of these steps does your product need?

If you can use skills and close tolerances like these, write for information to *Forge & Fittings Division, H. K. Porter Company, Inc., Cleveland 4, Ohio.*

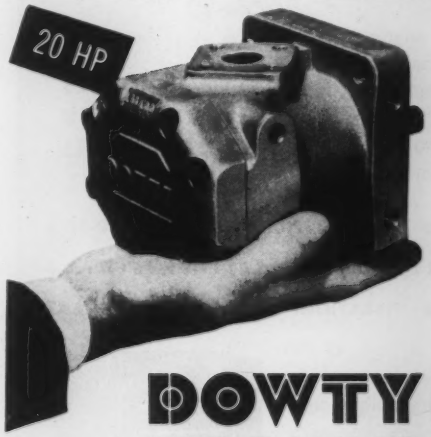
FROM A SINGLE SOURCE:

FORGINGS . . . Hammer, Press, Upset
MACHINING . . . Broaching, Milling, Turning, Drilling, Grinding
FINISHING . . . Heat Treating, Assembling, Painting, Plating

FORGE & FITTINGS DIVISION PORTER *H.K.PORTER COMPANY, INC.*

PORTER SERVES INDUSTRY with 12 DIVISIONS including: Thermoid, Delta-Star Electric, National Electric, Riverside-Alloy Metal, Refractories, Connors Steel, Vulcan-Kidd Steel, Forge and Fittings, Disston, Leschen Wire Rope, Mouldings and H. K. Porter Company (Canada) Ltd.

Circle 675 on Page 19



A HANDFUL OF POWER

DOWTY Pressure Balanced HYDRAULIC GEAR PUMPS

Pressures to 2500 PSI • Outputs from 1/2-60 GPM

Shown here is our Model GP2-85 which will deliver 18 GPM at pressures to 2000 PSI. Volumetric efficiency exceeds 95% throughout the operating range. Fully pressurized lubrication independent of discharge pressure. 14 other sizes available.

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Circle 586 on Page 19

IN A DESIGN SQUEEZE?

OPEN UP

...with the all-new PM-1 line of permanent-magnet d-c motors for your hard-to-fit applications. Only ⅞ inches in diameter, under 2 inches long and weighing less than 2½ ounces, these motors give you equivalent output power with ⅓ less bulk than older designs. And they're self-shielding.

Motors are available governed or ungoverned, with a choice of bearings, shaft extensions, and mounting arrangements; gear motors with various speed reductions. Modifications can be made to meet military and other special requirements.

ONLY ⅞ INCHES IN DIAMETER JUST 2½ OUNCES

- **STOCK MODELS FROM 4-30 VDC**
- **EFFICIENCIES FROM 40-50%**
- **CERAMIC FIELD STRUCTURE**
- **SELF-SHIELDING**
- **SPEEDS TO 20,000 RPM**
- **VIBRATION- AND SHOCK-RESISTANT**

WRITE TODAY for complete specifications, including information about Reflectone's unique self-contained POWER-PAK, a complete, compact electromechanical subassembly to simplify your design problem. One component provides mechanical output and d-c power for associated circuitry from AC, DC or self-contained battery.

"THE D-C WAY IS THE MODERN WAY"

Design d-c for maximum flexibility, portability, simplicity and dependability.

REFLECTONE

THE REFLECTONE CORP. • STAMFORD, CONNECTICUT

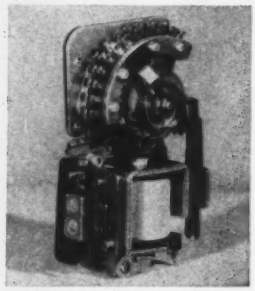
rent of 3 amp and minimum large-signal current gain of 30 for collector current of 0.5 amp. **CBS Electronics**, 100 Endicott St., Danvers, Mass. B

Circle 786 on Page 19

Stepping Switch

is 11-point, spring-driven type

Type 211 stepping switch eliminates pawl bearings and incorporates heavy-duty armature bearings and arms. Spring-driven switch accommodates twelve 11-point levels and



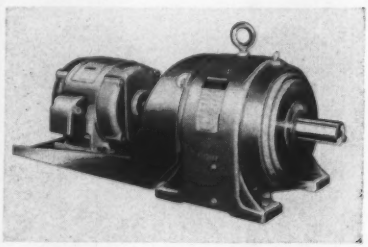
up to four 33-point levels. It operates for approximately 100 million steps between adjustments. **C. P. Clare & Co.**, 3101 Pratt Blvd., Chicago 45, Ill. I

Circle 787 on Page 19

Gear Reducers

accommodate separate, standard NEMA motors

Line of standard gear reducers has mounting facilities to accommodate separate, coupling-connected Lima standard NEMA motors of suitable horsepower, speed, and electrical characteristics. Reducers are available for horizontal foot-mounted application, in either double or triple-reduction units. Double-reduction units have 1 through 125-hp range, with reductions from 230 to 45 rpm. Triple-reduction units range from 1 to 50 hp, with reduc-



THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

CONCERNING PRECISION AND PHOTOSENSITIVE GLASS

Pure precision, in any form you like . . . how? With photosensitive glass!

What could be more precise than present-day photography? What more precise than "chemical etching" which works discretely on the molecular level and does away with the variables that invariably follow such operations as grinding, drilling, cutting and engraving?

What, indeed, when we can put exactly 250,000 holes on a plate only an inch square! Each of the holes can be *precisely* the same as its 249,999 companions; they can be square or even triangular. A change in size, shape or number of holes requires only a change in negative.

Such precision is not a drawing board dream. People are *using* photosensitive glass right now: for fine-mesh 500-line screen, for brush holders for digital computers, for various substrates, for printed circuits, for micro-module wafers, for attenuator plates, for dielectric spacers and for evaporation marks.

For more details, send the coupon for a copy of our bulletin on FOTOFORM® glasses.

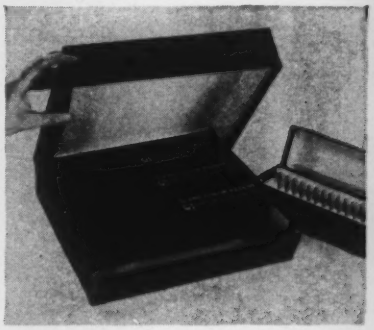
GOOD HOUSEKEEPING

If you have 2″ x 2″ light filters, are not quite happy with your facilities to store them, and would like to correct the situation, read on.

For only ten dollars we offer this compact kit of four sturdy boxes which were just *made* for holding filters. There's room for eighty filters to rest safely in slotted softwood. The boxes are covered in good-looking, long-wearing buckram.

If you'd like some fresh filters to put in the files, we have a complete set, or any part thereof, available. For three hundred and sixty dollars we'll send you the complete set of sixty-seven, including:

6 ultraviolet-transmitting, clear filters
6 ultraviolet-transmitting, visible absorbing
7 blue
7 blue-green
6 green
18 sharp cut
5 yellow
8 infrared
4 miscellaneous



We are not averse to splitting these sets if you have specialized wants. We can also provide 3⅛″ x 6½″ squares of those same filters, but without the box.

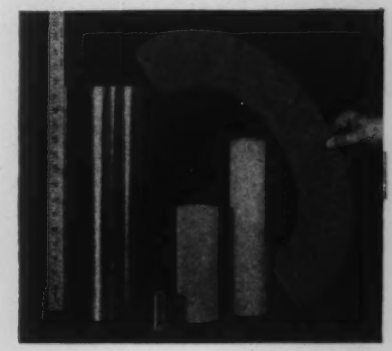
For more information on both box and filters, check the coupon.

TOO PURE TO TOUCH? "AIRLIFT" YOUR PRODUCT.

Molten metal slips down a chute without ever actually touching the chute.

Film and foil flash by over rollers without even touching them.

Tricks like these are accomplished with chutes and rollers made from a relatively new kind of nickel*—with pores in it. Air or some other gas is forced through these pores, and a cushion of gas forms to gentle products along, without a touch of contamination or scratches.



We make the porous nickel in tubes, cylinders, hemicylinders, and flat sheets up to 24″ long. We add holes or projections without secondary finishing. We do any machining needed.

Pores run with a high degree of uniformity in diameters from 1 to 45 microns, depending on space. Yield strength is a full 20,000 psi. Maximum working temperature is 300° C.

We welcome your questions, your specs, your orders.

***Of course, we realize that nickel is far removed from glass, but we figure that the people who read "This Is Glass" are the very people who will be interested in porous nickel.**

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 52-9 Crystal St., Corning, N.Y.

Please rush along: ☐ Information on color filters ☐ Bulletin on FOTOFORM Glass ☐ Data on porous nickel and also_____

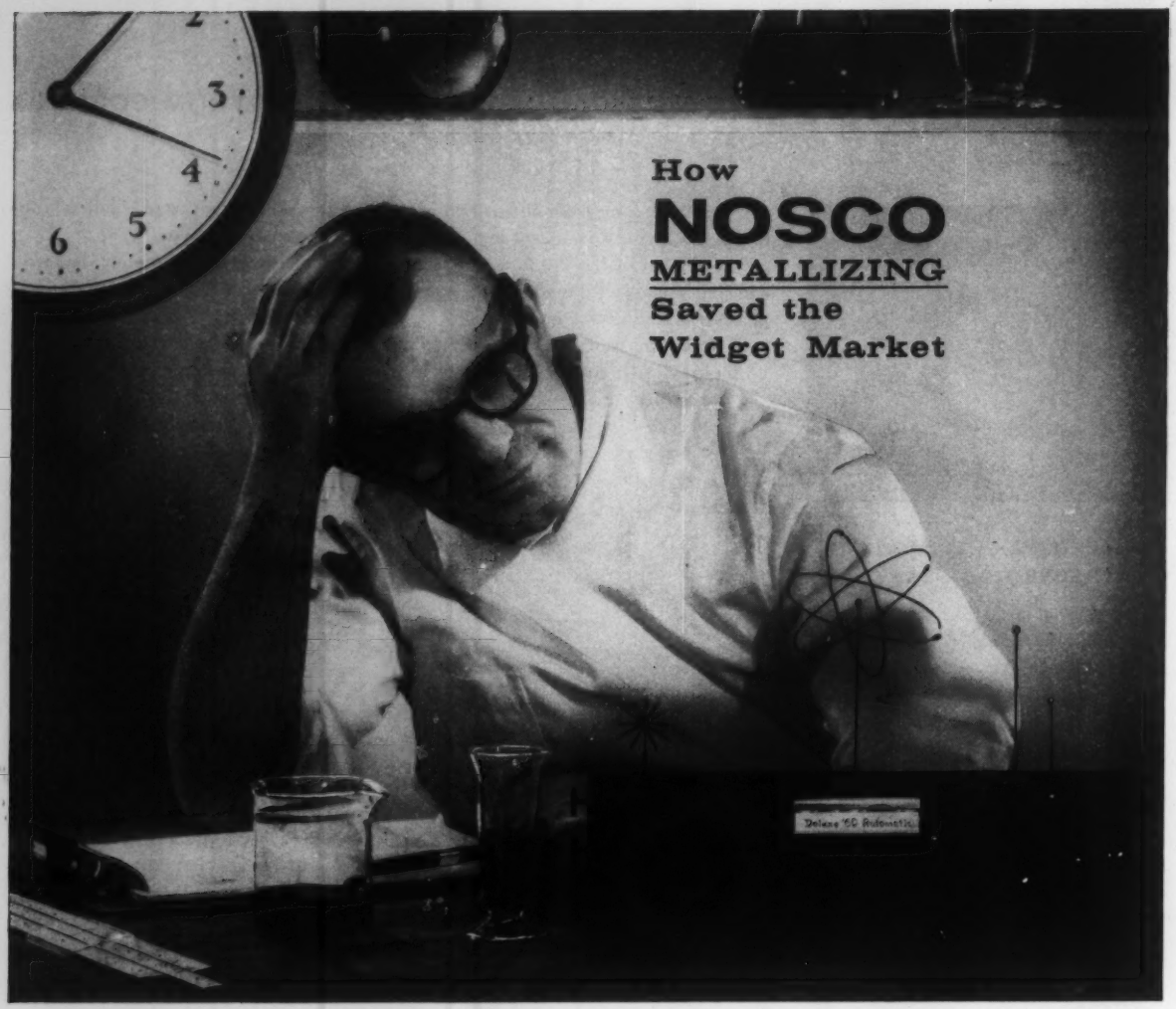
Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

Circle 588 on Page 19

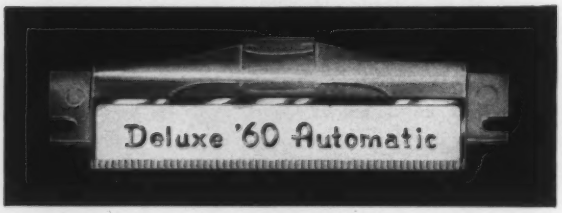


Once upon a time, in a bright shiny research laboratory, there lived a bright young inventor. He could invent the best anything — everyone knew that. He should have been the happiest inventor in the whole world. But he wasn't.

The problem was his newest machine, the double-reverse-widget, the biggest, best, lowest priced, most . . . But, you have the idea. It should have been a best seller. But it wasn't.

The double-reverse-widget lacked eye appeal. But re-designing was impossible, because everyone knows widgets have a very short selling season. So the inventor grew sadder . . . until Nosco's "Can Do" man arrived and suggested plastic metallizing.

Together they quickly sketched a low-cost nameplate with gold, silver and vivid colors proclaiming this widget to be the most. Nosco put the sketch into practical design and produced thousands almost overnight . . . because they back up "Can Do" with automated metallizing facilities, mechanical spray painting, quality-controlled hot stamping and apple pie order in all their production processing, as everyone well knows.



The rest is history. With the nameplate, sales skyrocketed and the bright young inventor was happy. And he stays happy by always checking to see how Nosco "Can Do" will help all his new projects.

Metallizing can add punch to your items, too. And Nosco's complete facilities guarantee fast service, plus top quality and production cost savings. To learn exactly how you can benefit, just write or call.

NOSCO plastics, inc. · erie 5, pa. *One of the world's great injection molders.*

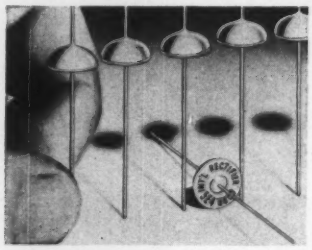
tions from 37 to 7½ rpm. Motor-mounting stresses cannot affect shaft alignment. Extra-capacity bearings supported in a rigid, strong housing make high overhung load ratings possible. **Lima Electric Motor Co. Inc.**, Dept. 139, Lima, Ohio. G

Circle 788 on Page 19

Silicon Diodes

are low-cost, high-temperature units

Specifically designed for television, radio, and commercial equipment applications where high temperature is required, low-cost, high-temperature, 400-peak inverse voltage-rated silicon diodes are operable to 70 C ambient temperature (100 C case temperature). The 2E4 diode is rated at 200 ma at 400 piv, and 5E4 unit is rated at 350 ma at 400 piv. All diodes are multisealed



with successive layers of humidity-resistant insulating resins and sealants, assuring optimum protection against environmental extremes, shock, and vibration. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif. L

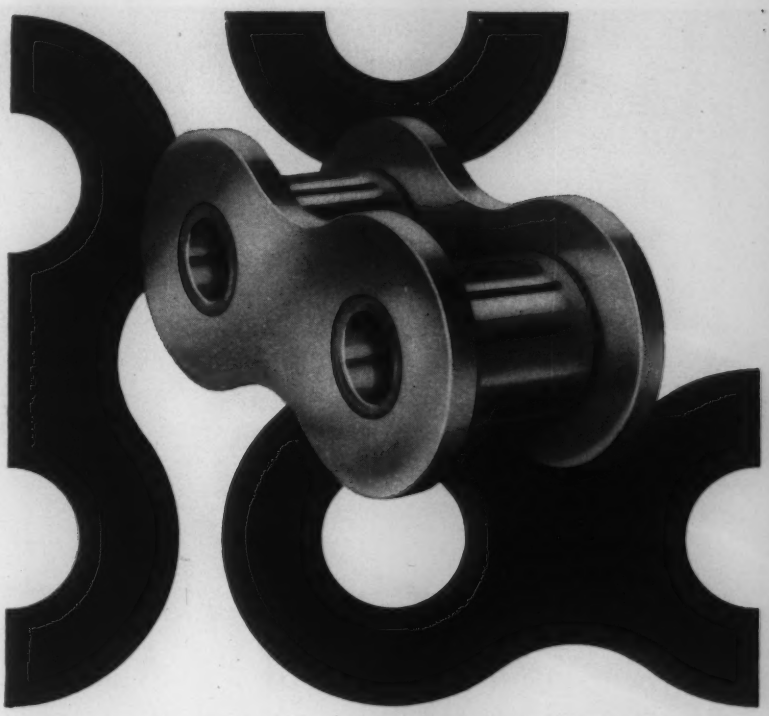
Circle 789 on Page 19

Slip-Ring Assemblies

are miniature, cartridge-type units

Miniature and subminiature cartridge-type slip-ring assemblies have double - bearing - mounted rotors, and noise levels consistently maintained at less than 50 mu v. All lead wires are stranded Teflon covered. Two brushes per ring are tuned to different resonant frequencies to insure electrical continuity despite severe shock and vibration. Operating temperature range is −65 to +350 F. Units comply with all requirements of

(*Please turn to Page 302*)



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WHITNEY PROCESSED CHAIN FOR BETTER DRIVE DESIGN LONGER SERVICE LIFE

Whitney's *fatigue-resistant* Processed Roller Chain Drives are setting new service records in every field. Important Whitney developments now supply *increased endurance, greater dynamic strength* for the toughest problem drives . . . for special power transmission and conveying requirements.

These developments include:

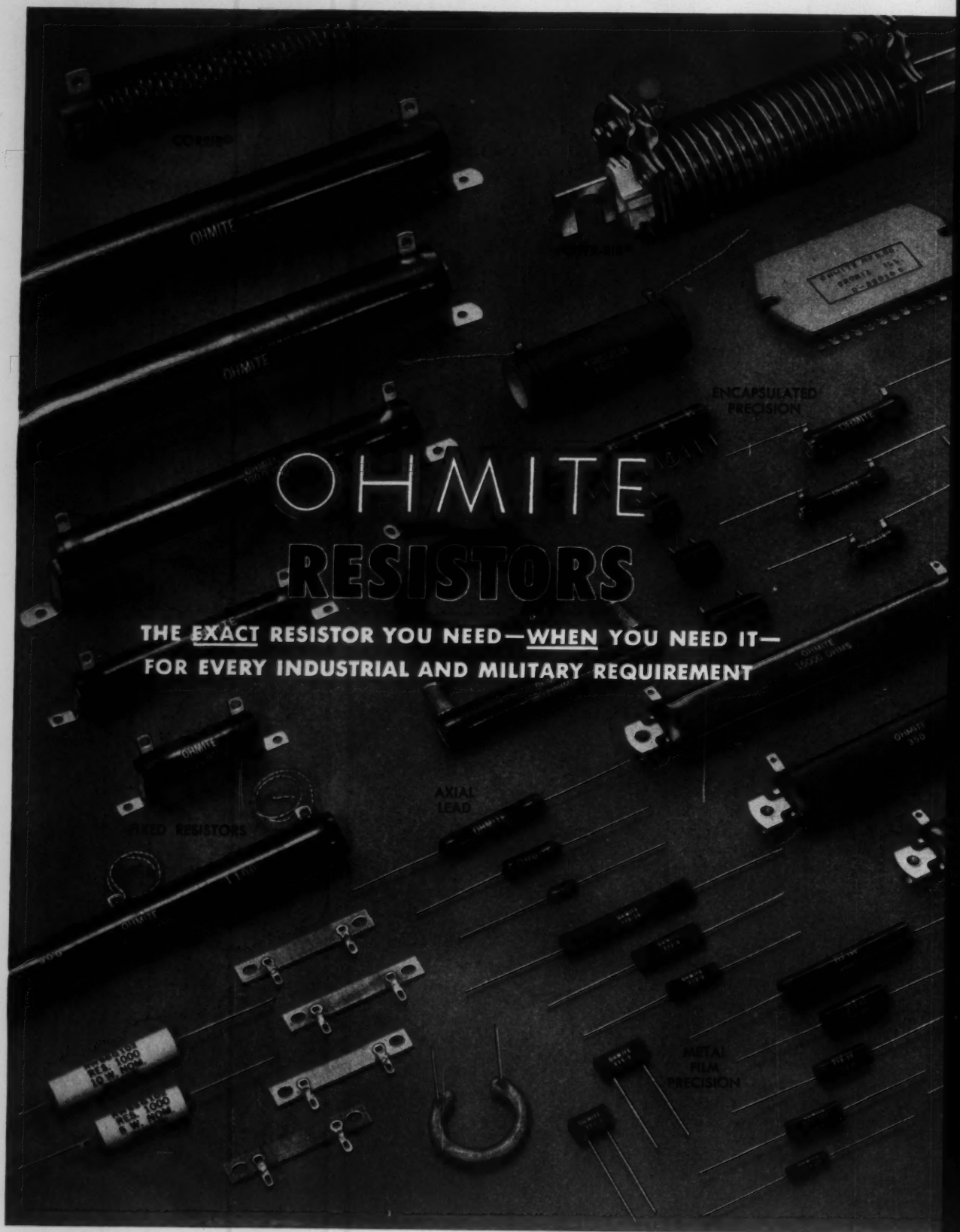
- **Patented process which imparts beneficial stresses to critical internal surfaces of chain rollers for greater fatigue life. This roller treatment is possible only through the Whitney process.**
- **Unique compressive technique applied to heat treated alloy steel chain links builds in concentrated residual stresses in the pitch hole area for greater dynamic strength.**
- **Shotpeening of components raise endurance limits to accept higher loadings imposed by modern drive demands.**

Your Whitney Factory or Field Service Engineer will gladly explain how these quality cost-saving features can be selectively applied to your present equipment or drive design for maximum performance.

And Whitney's complete line of standard, finished steel chain drives insure adaptability to the widest range of power transmission and conveying requirements. Available through field warehouses and nationwide distributor service. Write for helpful, practical catalog literature.

Whitney *Advanced Design Is a Whitney Tradition*
CHAIN COMPANY
A Subsidiary of Foote Bros. Gear and Machine Corporation | 4567 S. WESTERN BOULEVARD CHICAGO 9, ILLINOIS

Circle 590 on Page 19


OHMITE
RESISTORS
THE EXACT RESISTOR YOU NEED—WHEN YOU NEED IT—
FOR EVERY INDUSTRIAL AND MILITARY REQUIREMENT
ENCAPSULATED
PRECISION
AXIAL
LEAD
METAL
FILM
PRECISION

Fixed . . . adjustable . . . tapped . . . noninductive . . . precision metal film and encapsulated wire-wound . . . thin type . . . high-current—practically anything you need, whether it be for commercial or military equipment, you can find in the Ohmite line. It's the most comprehensive, most complete selection available to resistor users.

WORLD'S LARGEST STOCK FOR IMMEDIATE DELIVERY—You don't have to assume that the resistor you need is special. Chances are Ohmite's huge stock of several million resistors in more than 2000 sizes and types contains a unit that fits your requirements. Many types of Ohmite resistors are also available from stock, locally, through hundreds of Electronic Parts Distributors located across the Nation.

If, however, you do need special resistors, Ohmite can make them promptly to your exact needs—including a *complete line of units that meet military specification MIL-R-26.*

YOUR CUSTOMERS KNOW THE VALUE OF OHMITE QUALITY—When a purchaser sees Ohmite resistors in a piece of equipment, he knows that equipment is designed and built for dependability. He knows about the quality features found in Ohmite resistors—features such as balanced thermal expansion of all parts in vitreous-enameled power resistors, plus all-welded construction. He knows there are no thin spots in the coating, no cracks or crazing to let moisture in. He also knows of the exhaustive tests behind Ohmite units which are coated with silicone-ceramic, epoxy resin, and other materials.

OHMITE ENGINEERING ASSISTANCE ASSURES THE RIGHT UNIT—Selecting the right resistor for the job is sometimes a tough proposition. Why not call on Ohmite application engineers to help out. Take advantage of their specialized skills and background. You'll get the exact resistor you need and in a lot less time. Contact them today.

Write on Company Letterhead for Catalog and Engineering Manual 58

OHMITE®

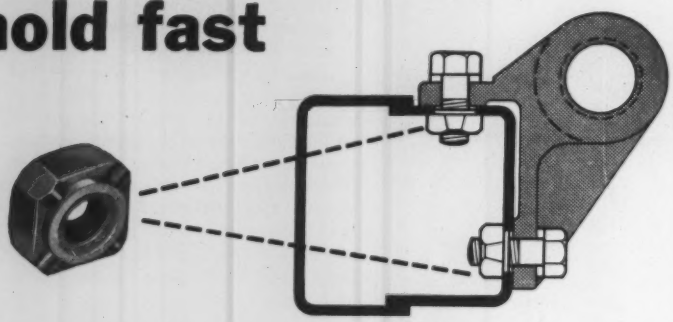
Quality Components

OHMITE MANUFACTURING COMPANY
3618 Howard Street, Skokie, Illinois

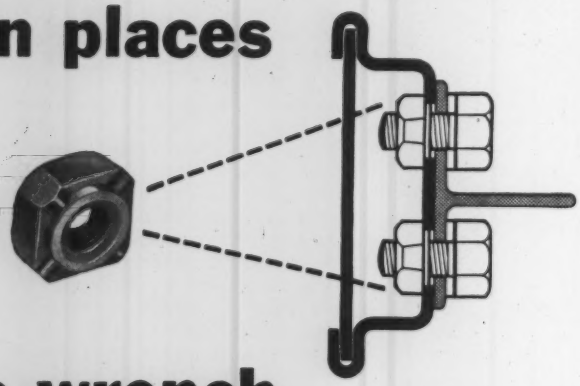
RHEOSTATS RESISTORS RELAYS
TAP SWITCHES R.F. CHOKES
VARIABLE TRANSFORMERS
TANTALUM CAPACITORS
GERMANIUM DIODES

Circle 592 on Page 19

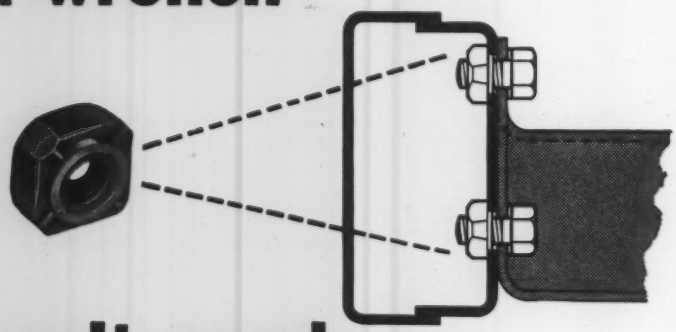
MIDLAND
WELDING NUTS
hold fast



in places



a wrench



can't reach

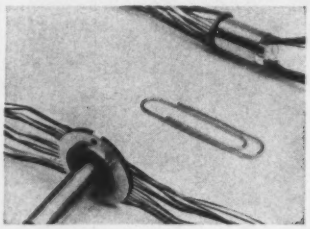
Looking for cost and time-saving tips? Send for the free booklet showing you how to "Save With Midland Welding Nuts."

MIDLAND-ROSS CORPORATION
OWOSSO DIVISION • OWOSSO, MICHIGAN

MIDLAND WELD NUT

Circle 593 on Page 19

(Continued from Page 299)



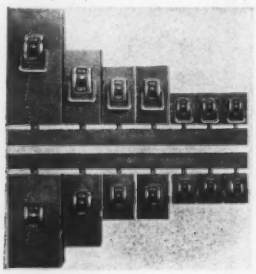
MIL-E-5400C. Miniature assemblies have 12 to 100 circuits, and subminiature units have 12 to 50 circuits. **Slip Ring Co. of America,** 13000 S. Avalon Blvd., Los Angeles 61, Calif. L

Circle 790 on Page 19

Safety Switches

for close-ganged installation

Bottom hinging and front operation on 30 through 600-amp safety switches permit economies in space where limited mounting space is available. Devices can be ganged virtually one against the other, since there is no projecting mechanism or hardware on sides of



switches. Bottom-hinged cover detaches by removing only one screw. Units are available in both heavy (top) and light-duty (bottom) types. **Distribution Unit, General Electric Co.,** Plainville, Conn. B

Circle 791 on Page 19

All-Porcelain Strainer

for use with process equipment

All-porcelain strainer removes both coarse and fine solids before they enter chemical pumps, valves, or other process equipment. End seal is Teflon, and connecting flanges are malleable iron and are drilled for 150 ASME bolting. All other trim is stainless steel. Strainer element of fused porcelain sand pro-

6-Way Motor Burnout Protection* Means Total Protection...

**Ask your motor manufacturer about it*

and only the New KLIXON Type T Protectors Provide It!

Most conventional protectors used today may protect motors against up to four overheat conditions. KLIXON Type T Protectors safeguard motors from all six conditions:

1. Running overload with or without high ambient or ventilation blocked.
2. Locked rotor normal voltage such as caused by mechanical failure of driven load.
3. Locked rotor caused by low voltage where decreased torque is insufficient to start load.
4. Locked rotor with main winding only in circuit resulting from open circuit start switch or open circuit in reversing switch.
5. Locked rotor with start winding only in circuit, such as that resulting from an open main winding circuit or open circuit in reversing switch.
6. Running with both start and main windings in the circuit resulting from start switch failure in closed position or low voltage which prevents reaching switchover speed.

Manufacturers of motor-driven equipment can obtain induction motors that have *complete protection against all possible conditions that cause overheating and burnouts* simply by specifying on their motor purchase orders — "These motors to have KLIXON Type T Protectors." KLIXON Protectors permit motors to operate at safe maximum output without premature motor failures. They build customer goodwill by reducing costly motor repairs, replacements and service calls. Get TOTAL PROTECTION for your motor-driven equipment . . . use motors with built-in KLIXON Type T Protectors.

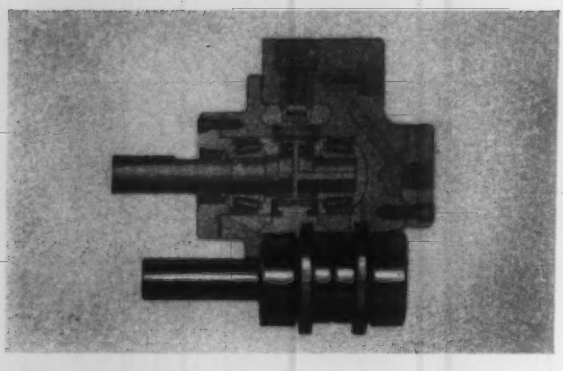
Over 150,000,000 motors are protected against overheating and burning out with KLIXON *Protectors.*

METALS & CONTROLS
3209 FOREST STREET, ATTLEBORO, MASS., U. S. A.
A DIVISION OF TEXAS INSTRUMENTS INCORPORATED

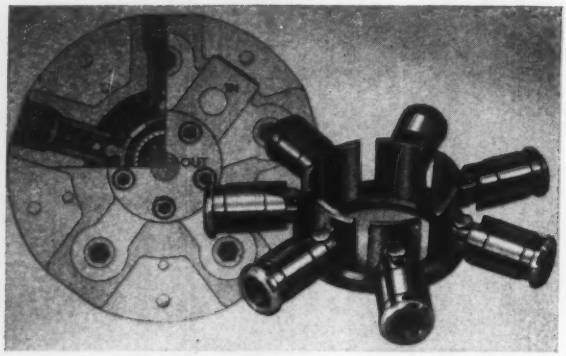
SPENCER PRODUCTS: Klixon® Inherent Overheat Motor Protectors • Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

FOR PRESSURES TO 5,000 PSI . . .

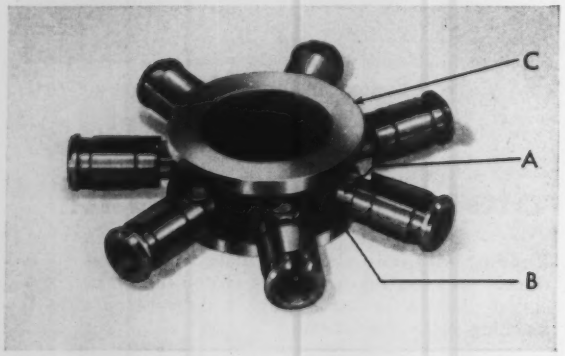
Only the AE Hydramite gives you these 4 key benefits



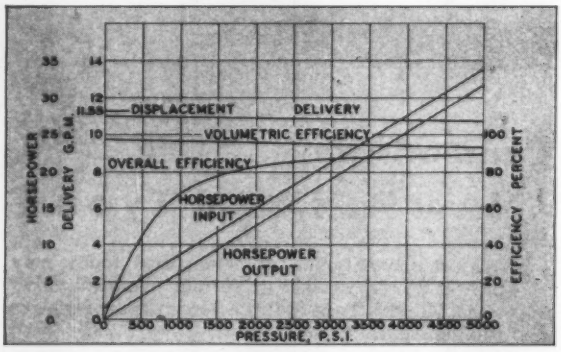
1. Tapered roller bearings. Two high capacity, heavy duty tapered roller bearings support the eccentric cam shaft. This means that a Hydramite can take more punishment . . . handle heavier unbalanced loads . . . and last longer. The pump casing is ported so that the pumping action of tapered bearings will provide better lubrication.



2. Curved slippers riding on the outer race of the cam shaft needle bearing minimizes scrubbing action between these parts. They also distribute thrust loads of the plungers and reduce unit stresses to the point where maintenance will never be required at what is a critical wear point in most hydraulic pumps.



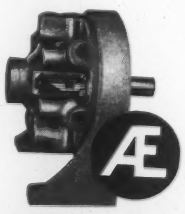
3. Positive pumping action. The Hydramite has no cam follower springs to fail. Plungers (A) are connected to curved slippers (B) which are held against the outer race of cam shaft needle bearing by two plunger return rings (C). As the shaft revolves, each plunger is pushed outward in succession and then pulled back by the return rings.



4. High efficiency. With a Hydramite you get an overall efficiency of 85%. Shown above is typical 10 gpm pump curve. Its flat overall high efficiency has little variation between 1,500 and 5,000 psi. What's more, with a Hydramite you get positive suction. There is no need for supercharging equipment which reduces system efficiency.

To meet your specific requirements, Hydramite pumps can be supplied for constant displacement from 3 to 30 gpm at 5,000 psi and 70 to 85 gpm at 3,000 psi for hydraulic fluids with viscosities of 150 to 300 ssu at 100° F. In special applications they have handled viscosities as low as 40 and as high as 900 ssu at 100° F.

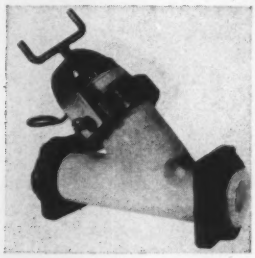
Special materials and seals permit handling of missile fuels and special fluids at higher temperatures. Available in flange, foot or face mounted styles. Write or call American Engineering Company, Dept. P-147, Philadelphia 37, Pa. Phone: CUmberland 9-3800.



AMERICAN ENGINEERING COMPANY

Hele-Shaw Pumps, Lo-Hed Hoists, AE Marine Deck Auxiliaries, Vibra Grate, Perfect Spread and Taylor Stokers.

Circle 595 on Page 19

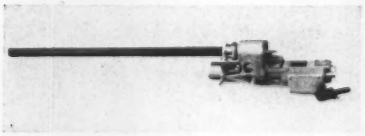


vides chemical resistance and controlled porosity. It can be removed easily for cleaning or replacement. Coarse strainer element has average pore diameter of 250 mu, medium strainer, 150 mu, and fine unit, 110 mu. **Process Equipment Div., Lapp Insulator Co.**, 106 Hall St., LeRoy, N. Y. N

Circle 792 on Page 19

Linear Actuator
has 31-in. stroke

Model D-1870 linear actuator has a normal load of 300 lb at 3.5 ips travel rate, and stroke of 31 in. Unit operates on 28 v dc. Electrical load-sensing mechanism permits actuator to sense, shut off, and hold predetermined load of 500 to 800 lb. Actuator is built to utilize three major subassemblies: Motor and clutch-brake assembly with integral thermal protector; junction box with



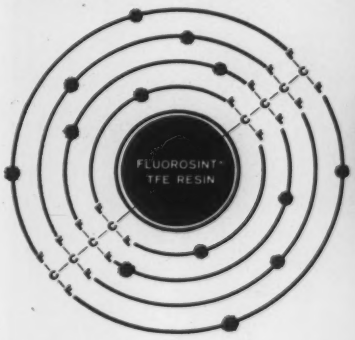
electrical components; gearbox and jackscrew. Each subassembly can be removed separately for repair or replacement. **Hoover Electric Co.**, 2100 S. Stoner Ave., Los Angeles 25, Calif. G

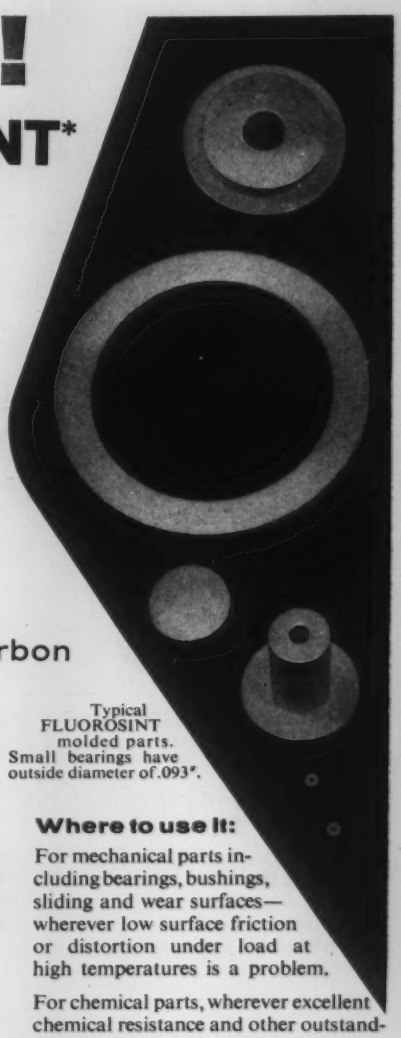
Circle 793 on Page 19

On-Off Indicator
withstands ambient temperatures over 350 F

New type on-off indicator, of coil and armature construction, is extremely small in size, light in weight, and resistant to shock, high ambient temperatures, and environments. Unit is available with either a pointer or an enclosed, hermetically sealed shutter arrangement as

NOW!
FLUOROSINT*
mill shapes and molded parts





A new TFE Fluorocarbon base resin

...with improved mechanical and thermal properties

Typical FLUOROSINT molded parts. Small bearings have outside diameter of .093".

What it is:

FLUOROSINT TFE resin, a product of extensive research, combines TFE fluorocarbon resin with specially developed constituents to improve its mechanical and thermal properties.

What it offers:

Low thermal expansion (similar to aluminum)—one-sixth that of Teflon† TFE fluorocarbons.

Improved bearing and wear characteristics. Bearings operate at higher loads and speeds.

Increased rigidity and reduced deformation under load, at both low and high temperatures.

Notable freedom from stresses and distortion on thermal shock or temperature cycling.

Close molding tolerances on molded parts—tests indicate one-third to one-sixth the limits obtainable with unmodified Teflon (TFE).

Chemical and electrical properties similar to unmodified Teflon (TFE).

Where to use it:

For mechanical parts including bearings, bushings, sliding and wear surfaces—wherever low surface friction or distortion under load at high temperatures is a problem.

For chemical parts, wherever excellent chemical resistance and other outstanding advantages are indicated, such as parts operating in corrosive conditions or under water.

For electrical parts, where its heat and moisture resistance and low thermal expansion make it ideal for stand-off insulation or insulating wear parts.

* * *

Polymer's sales and technical service staff are available for help on your applications. Write today for new technical bulletin.

Molded parts are available from Halex Corporation, Detroit, Michigan, a Polymer Corporation subsidiary.

The Polymer Corporation of Penna.
Reading, Pa.

Manufacturers of quality mill shapes of TFE fluorocarbon resins

Export: Polypenco, Inc., Reading, Pa., U.S.A.

*Trademark of The Polymer Corporation
†Du Pont Trademark for Fluorocarbon resins

POLYPENCO

Circle 596 on Page 19

H&S

WORM-GEAR SETS
insure smooth driving action between perfectly mated members

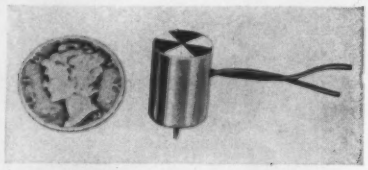
Check these important advantages for your power transmission needs:

Smoothness of Operation • Ability to Carry Heavy Shock Loads
Compactness • Large Ratios • Reliability
Long Service Life • Self-Locking

Horsburgh and Scott worm-gear generating methods guarantee perfect mates in each set, with worm threads and gear teeth having identical pressure angles and tooth contours. Resultant smooth conjugate action delivers maximum right angle power transmission with minimum power loss. H&S gives each set a controlled inspection on the correct center distance for tooth contact, backlash and smoothness.

To meet your requirements H&S makes Worm Gears up to 60 inches diameter—circular pitch range from ¼" to 3½". Ratios can be furnished from 3-5/9:1 to 100:1 . . . For prompt response from H&S engineers, just send an outline of your needs.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio



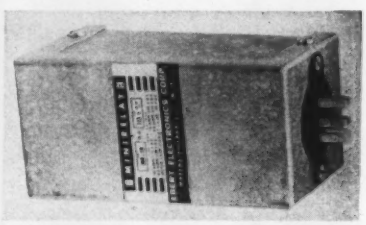
an indicator. Indicator operates directly on any voltage to and exceeding 120 v at frequencies to 2500 cps without rectification and on ac or dc. It weighs 3.7 grams, withstands ambient temperatures exceeding 350 F, is easily mounted, and offers extremely low power consumption and heat dissipation. **Leetronics Inc.**, 30 Main St., Brooklyn 1, N. Y. D

Circle 794 on Page 19

Mercury Plunger Relays

are plug-in types

MiniRelay plug-in mercury plunger relays are available in one and two-pole types. Normally open or normally closed contacts are available in single-pole unit and in combinations of contacts for two-pole device. Single-pole MR-10PL (shown) is 4 in. high, 2¼ in. deep, 2¼ in. wide, and is rated at 20 amp at 115 v ac. Units are suited for power supply, motor control, or any cir-



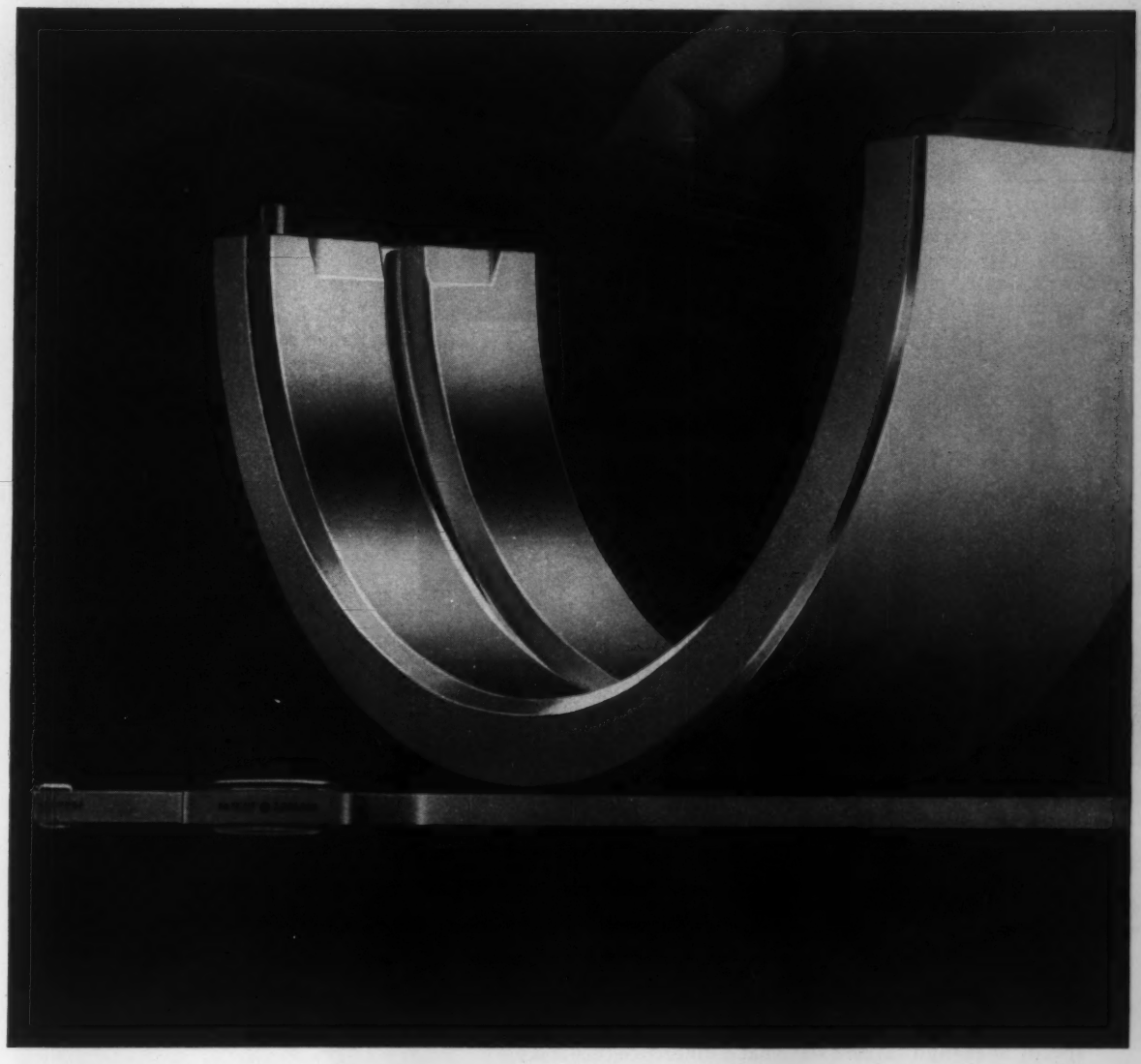
cuit requiring plug-in facility. **Ebert Electronics Corp.**, 212-320 Jamaica Ave., Queens Village 28, N. Y. D

Circle 795 on Page 19

Redesigned Gearheads

for use on stepless adjustable-speed drives

Zero-Max gearheads now have double spur gears to increase speed or torque. New shape of gearhead housing provides for more rigid mounting to Zero-Max stepless adjustable-speed drives. Gearheads increase range of drives from 120 to 150 lb-in. torque with adjustable speeds of 0-80 to 0-2000 rpm. Available gearhead ratios are 1:2, 1:3,



why use 19th century metals to carry 20th century loads?

for solid bearings, Alcoa Aluminum far outperforms old-fashioned metals ...and costs far less. Here are the facts:

DESIGNERS of a century and more ago *had* to rely on bearings of babbitt or bronze; better bearing metals just didn't exist.

BUT WHY should *you?* Not *cost*, certainly, for a typical aluminum alloy bearing sleeve costs as much as one-third less than other materials.

PERFORMANCE? Solid aluminum bearings support up to 10,000 pounds per square inch. Years of service in a host of applications from railroads to rolling mills show ability to stand up long after inferior metals have failed. Aluminum bearings run cooler—as much as 20° by actual test—because *no* other bearing metal is as good a heat conductor.

AND ALUMINUM bearings *last longer*, because they conform, thanks to aluminum's famous ductility. Because of aluminum's famed resistance to corrosion, especially to additives in lubricating oils. Because it embeds gritty particles that might cause abrasive wear and scoring. Because of their lower frictional resistance under heavy load, aluminum bearings permit immediate starting.

SO WHY rely on old-fashioned bearing materials? *Design around aluminum*—for maximum flexibility, optimum performance, minimum cost.

For further details, call your nearest Alcoa sales office, or write: Aluminum Company of America, 1837-J Alcoa Building, Pittsburgh 19, Pa.

Aluminum Bar Stock Now Available Locally!

Your nearby Bunting Distributor can now quickly fill your replacement bushing needs with cost-saving, high-performing Alcoa® Aluminum bars. He carries a complete line of 138 different sizes in solid and cored aluminum bar stock.

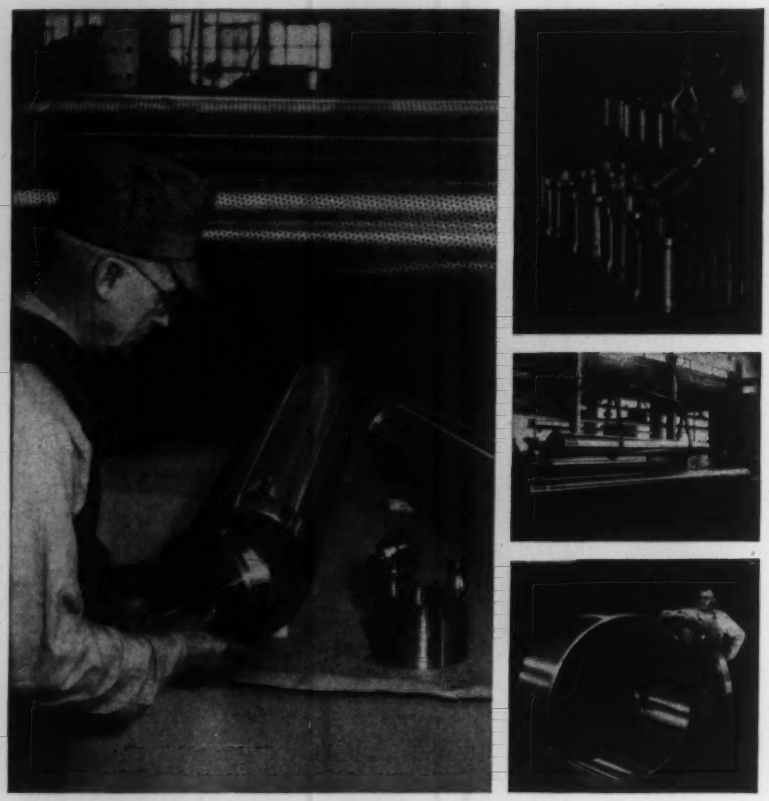
Call your Bunting Distributor for Alcoa Aluminum bars and save as much as 33⅓ per cent on your replacement bushing costs.

ALCOA ALUMINUM

Your Guide to the Best in Aluminum Value

For Exciting Drama Watch "Alcoa Theatre," Alternate Mondays, NBC-TV, and "Alcoa Presents," Every Tuesday, ABC-TV

Circle 598 on Page 19



Your parts last longer when they're

SHENANGO CENTRIFUGAL CASTINGS

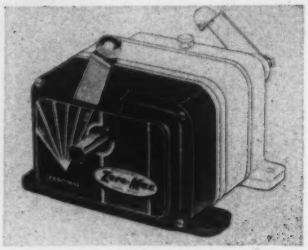
Your machine parts, ferrous or non-ferrous, are subject to stress, strain and friction, day after day, year after year . . . so specify Shenango . . . and see what a difference this makes!

Shenango's centrifugal casting process insures longer life because of finer, more uniform, *pressure-dense* grain to begin with . . . free of inclusions, porosity, blowholes and other weakening defects. Then, far less machining is needed and your part is stronger . . . to last and last *and last!*

Shenango's modern and fully-equipped shops will supply you with ferrous or non-ferrous symmetrical parts in virtually any shape or size . . . rough, semi-machined or precision-finished to your most exacting specifications. For full details, write: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, Ohio.

SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS



1:4, 1:5, and 5:1, 4:1, 3:1, 2:1, with torque constant and speed infinitely variable. New design provides quieter operation and permits location of control at front of rectangular case. Output shaft is located in center of unit on all models, whether used for increasing or reducing speed. **Zero-Max Co.,** 1900 Lyndale Ave., S., Minneapolis 5, Minn. J

Circle 796 on Page 19

Wire-Wound Resistor

is available in values from 1 to 25,000 ohms

PW 15 high-temperature wire-wound resistor is rated at 15 w. Alloy-coated leads for positive soldering are secured to a resistance element, uniformly and tightly wound on a glass-fiber core, and sealed in a rectangular case. All materials are inorganic for fullest protection against flame or decomposition at overload conditions. Unit is available in values from 1 to 25,000

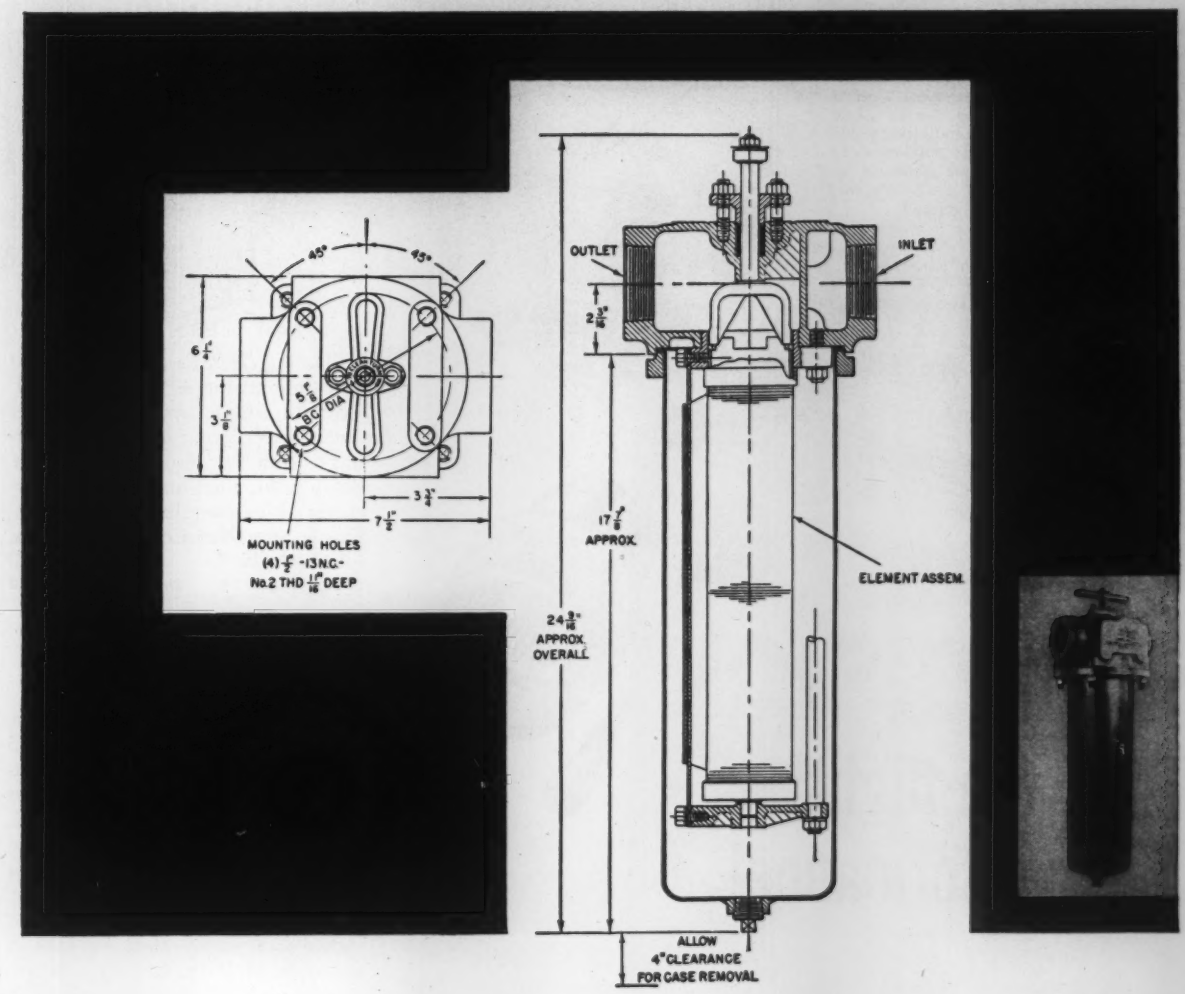
ohms, with standard 10 per cent tolerance, or 5 per cent on special order. **International Resistance Co.,** 401 N. Broad St., Philadelphia 8, Pa. E

Circle 797 on Page 19

Time-Delay Relay

miniature unit recycles instantaneously

Miniature time-delay relay is 4⅝ in. high, 1 13/16 in. wide, and 1½ in. deep. Unaffected by voltage variations, it recycles instantaneous-



This one standard Purolator filter is

EXACTLY RIGHT *for all these fluids:*

inks • paints • varnishes • food products • greases • process fluids • fuel and lube oils

SPECIFICATIONS: This Purolator filter model G-141J—is designed for filtration in a range upward of 40 microns.

It can be installed on pressure or suction side of pump.

It is recommended for capacities of from 6 to 200 GPM, dependent on viscosity. Spacing varies from .0010 to .020.

Relief valves set from 10-12 (generally 15 to 20) to 50 PSI are incorporated in several models.

Motor driven knife blade to clean element can be furnished whenever conditions make manual rotation impractical.

Maximum pressure: 125 PSI; weight: 37 lbs. Equipped with simplex full-flow metal element oil strainers.

Available in all stainless steel construction for corrosive liquids, process fluids, food products.

If this filter's specifications recommend it for a problem of yours, write for application information.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

Circle 600 on Page 19

Famous PRATT & WHITNEY AIRCRAFT J57 Jet Engine, power plant for Air Force "Snark" guided missile, is geared for both commercial and military performance by *Perkins*. Typical tolerances on *Perkins* gears: .0004 tooth to tooth; .0015 cumulative; .0005 on involute. On spline: .0006 tooth to tooth; .0008 cumulative; .0005 on involute. Most *Perkins* gears are carburized, hardened and ground.

PRECISION for top-flight performance!

Rigid PRATT & WHITNEY AIRCRAFT precision requirements spell *performance* . . . top-flight performance. Reason: The future is at stake. And that future can well ride on gear teeth. Since 1940, PRATT & WHITNEY AIRCRAFT gear tolerances have been *Perkins'* standards . . . for commercial gears as well as aircraft. Such precision pays off in longer wear, greater efficiency, lower maintenance cost. That type of precision can pay off for you, too.

This Handy Gear Calculator, easy to use, saves time. *Folder* illustrating Perkins custom precision gears and facilities offers information. Both yours on request.

PERKINS
MACHINE AND GEAR CO.

Dept. 53 West Springfield, Mass.
Telephone: REpublic 7-4751

Circle 601 on Page 19

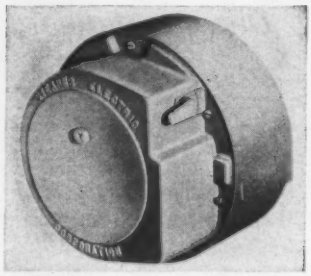
ly. Timing ranges are easily adjusted to a time setting as low as 30 millisec with repeat accuracy of 5 per cent. Three timing ranges cover settings from 30 millisec to 2 min. Relay is supplied for delay on energizing or de-energizing. **AGA Div., Elastic Stop Nut Corp. of America,** Elizabeth, N. J. D

Circle 798 on Page 19

Electric Brakes

in both ac and dc models

Series 42,000 brakes provide torque ratings of 125, 175, 230, and 575 lb-ft. Flange is suitable for mounting on NEMA C flanges of motor frames 324UC through 405UC. Brakes are available in both ac and dc models in either standard or dust-tight, waterproof enclosure. Entire operating mechanism is attached to a single plate for ease of assembly and disassembly. Brakes accept standard shaft length or a



shaft completely through the brake. **Stearns Electric Corp.,** 120 N. Broadway St., Milwaukee 2, Wis. K

Circle 799 on Page 19

Control Valve

has infinitely variable throttling

Straight-Flow control valve has flow moving in a direct, unrestricted straight line through valve at all throttling positions. This reduces

New Type AVR static-powered adjustable-speed drive

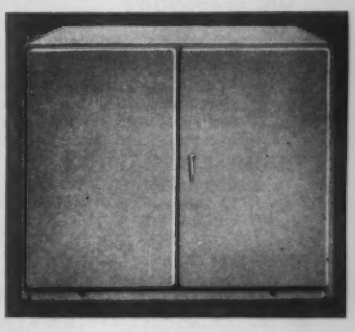
With the new Westinghouse static-powered AVR adjustable-speed drive, maintenance costs are virtually a thing of the past. Power magnetic amplifiers replace the conventional motor-generator set . . . there are no moving parts to weaken from wear and fail . . . you enjoy all the proven benefits of static control components.

Providing smooth, stepless speed control, new AVR drives are designed for use with motors from 1 to 200 hp . . . give you constant torque over an 8 to 1 speed range, or 10 to 1 with modification . . . are also available with constant-horsepower speed ranges.

New Westinghouse AVR drives are completely engineered, assembled and factory tested. They provide higher operating efficiency with greater reliability than heretofore obtainable from conventional drives. They simplify installation and reduce floor space required . . . sometimes as much as one-half the area of conventional M-G set drives.

Ask your Westinghouse sales engineer to show you exactly where and how you can benefit from new Westinghouse adjustable-speed drives. Or, write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania. J-22144

Also available . . . the standard Westinghouse AV drive with motor-generator type conversion.



YOU CAN BE SURE . . . IF IT'S **Westinghouse**

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV FRIDAYS

Circle 602 on Page 19

H&K perforated materials

a perfect medium of

DESIGN

with functional or decorative uses

Harrington & King can perforate the proper design, pattern and open area in practically any metallic or non-metallic material available in coils, sheets or plates—from foil-thin to 1" thick. Specify H&K perforated materials on your next job.

Write for General Catalog No. 75, Today!

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Chicago 44, Illinois

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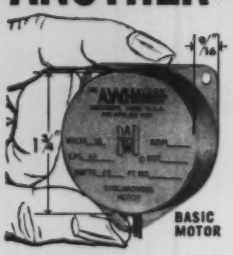
114 Liberty Street, Dept. MD
New York, New York

FIND NEAREST H&K AGENT in the 'Yellow Pages'
Listed Under "Perforated Metals"

Circle 603 on Page 19

ANOTHER FIRST...



THE ONLY *Electro-Reliable* A.C. TIMING MOTOR

Thinner... Quieter... More Reliable... More Versatile

FINGER-THIN...
Only 9/16 Inches Short... Only 1¾ Inches in Diameter... very compact... reduces the size of your equipment.

WHISPER-QUIET...
Strictly an electrical motor... practically noiseless... no rattling of gears or ratchets.

HIGH TORQUE...
¼ oz. inch at the rotor with an instantaneous start and stop... requires only 2½ watts... can replace larger motors in recorders, controls and telemetering equipment.

HIGHEST RELIABILITY...
Longer life... no one-way gears or ratchets to fail... provides millions of operations without any trouble.

SPECIFICATIONS

Standard Voltage Ratings: 6, 12, 24, 115, 230 Volts
Frequency: 60 CPS Standard; 25, 50 CPS Available
Power Input: 2.5 Watts Maximum (60 CPS)

BASIC MOTOR
Weight: 4 ounces
Speed: 300 RPM
Torque: ¼ oz-in.
Length: 9/16 inch

WITH INTEGRAL GEAR TRAIN
Weight: 5 ounces
Speed: 300 RPM to 1/6 RPH
Torque: 30 oz.-in. @ 1 RPM
Length: ⅞ inch

WITH INTEGRAL GEAR TRAIN

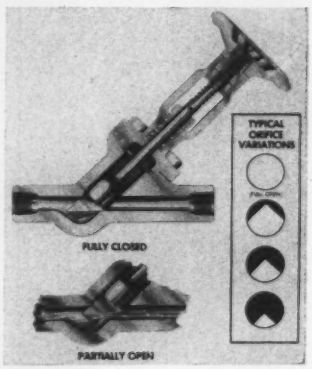
© 1959

Send for Special Illustrated Bulletin AWH MO-806

The A.W. HAYDON Company
249 NORTH ELM STREET
WATERBURY 20, CONNECTICUT
Custom Design & Manufacture Of Electronic And Electro-Mechanical Timing Devices

Circle 604 on Page 19

pressure drop and friction loss, and gives infinitely variable throttling. Principal advantage of the valve is its ability to pass a large volume of fluid or gas for a given pressure with little turbulence. All flow is concentrated in a triangle-shaped orifice instead of an annular ring, allowing passage of large particles of solid material at any given orifice, resisting clogging. Stem is fully stabilized at all throttling positions, eliminating tip vibration. Valve has outside stem and bonnet for corrosion resistance, and orifice opening is indicated on a calibration plate. Valve is carbon steel, stainless steel, or bronze. Pressure ratings range from 600 to 10,000 psi, and sizes are ⅛ to 4 in. General-American Valve Co., P. O. Box 444, Corona del Mar, Calif. L



Circle 800 on Page 19

Laminated Polyester Film

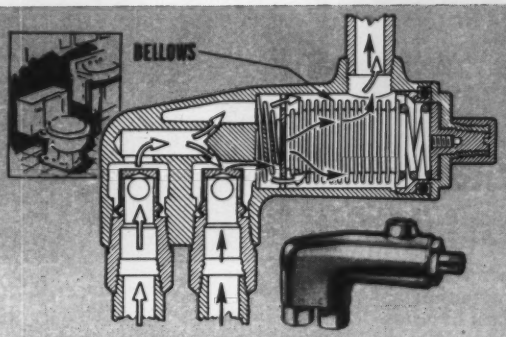
can be cold-formed to simple shapes

Lamicoid LPF-1 laminated polyester sheet consists of two plies of 0.01-in. thick polyester film which are laminated together, using special bonding agent. Resultant laminate can be cold-formed easily with simple wooden molds or punched into a variety of shapes and forms. Film has excellent flexibility and mechanical strength, good electric properties, high heat resistance, and excellent resistance to delamination. It can be creased repeatedly over itself or bent into small radii without cracking, breaking, or delaminating. Laminate also has excellent resistance to Freon 22 in sealed systems where no moisture is present. It is uniform in thickness,

DESIGN FOR

BEST PERFORMANCE, LOW COST

with **Flexonics** BELLOWS

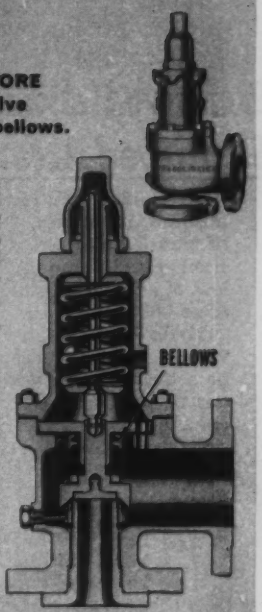


KOHLER of KOHLER eliminates closet condensation with thermostatic supply valve.

A Flexonics bronze bellows is the heart of the new Kohler thermostatic valve designed to mix water from the hot and cold lines to deliver tempered water to the closet tank . . . eliminating annoying condensation (sweating). The fast response of the bellows keeps water in perfect temperature balance . . . automatically. Valve requires no adjustment for seasonal variations in water temperature. Another example of the adaptability of Flexonics bellows in designing for best performance at low cost.

MANNING, MAXWELL & MOORE Consolidated Safety Relief Valve features FLEXONICS sealing bellows.

After long investigation and literally thousands of tests, a Flexonics stainless steel, two-ply bellows was selected for the Consolidated Safety Relief Valve. The bellows isolates contaminants, corrosion, or viscous fluids from the working parts of the valve. It is designed to allow a maximum variation in back pressure at the valve outlet while at the same time maintaining the important characteristics of high capacity, no change in set pressure, and limited blowdown changes.



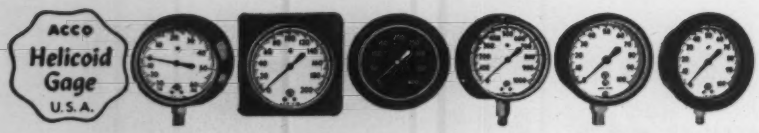
For design applications that involve the measurement of pressure or temperature...a flexible sealer...or even low-torque power transmission – a Flexonics Bellows can be your answer. Send an outline of your bellows application – the Flexonics Application Engineering Staff will be pleased to make recommendations. If you prefer *write for the Flexonics Bellows Design Guide . . . 20 pages of valuable information.*

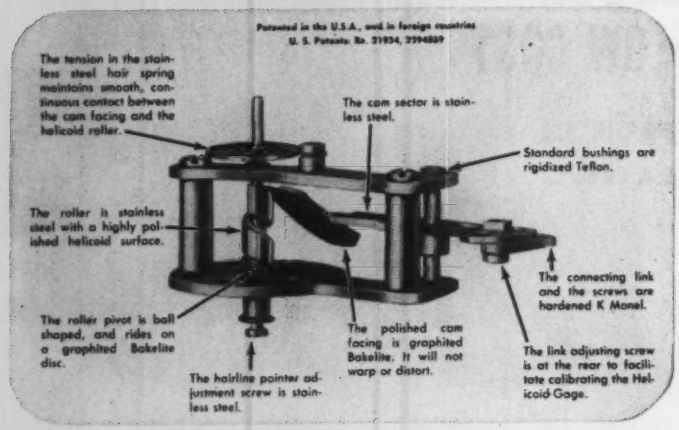
Flexonics
BELLOWS

FLEXONICS CORPORATION • 1339 S. THIRD AVENUE • MAYWOOD, ILLINOIS

Divisions
INDUSTRIAL HOSE • EXPANSION JOINT • BELLOWS • AERONAUTICAL • AUTOMOTIVE
Flexonics Research Laboratories, Elgin, Illinois
In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Circle 605 on Page 19





Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details

Ask for Catalog DH-65

HELICOID GAGES

Helicoid Gage Division • American Chain & Cable Company, Inc.
929-M Connecticut Ave., Bridgeport 2, Conn.

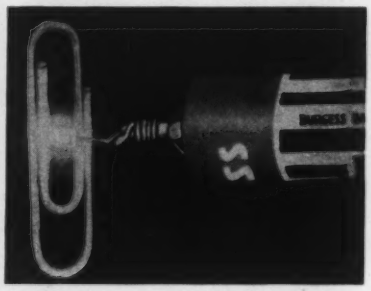
ACCO

translucent, smooth, and free from wrinkles or voids. Sheet is particularly adapted to applications requiring formation of simple shapes that are tough, flexible, and will hold their form. **Mica Insulator Div., Minnesota Mining & Mfg. Co.,** Schenectady 1, N. Y. C

Circle 801 on Page 19

Indicator Lamp

draws under 50 ma at 1.3 v



Microminiature incandescent indicator lamp operates directly from output of a transistor without amplification. It operates at less than 1.5 v and draws less than 50 ma. Unit is housed in a vial 0.11 in. long and 0.05 in. diam with two platinum leads extending from one end. Application is in computers and in a variety of military electronics devices where size and low-current requirement are important. **Minitron Components Corp.,** 67 Illinois Ave., Paterson, N. J. D

Circle 802 on Page 19

Synthetic Grease

resists gasoline, solvents, and water

Anderol L-237 is a medium-hard consistency synthetic grease that resists wipe-off or throw-off on valve applications. Inherent stability resists mechanical breakdown over temperature range of −20 to +300 F. Grease is completely resistant to gasoline, solvents, and water. Low evaporation rate maintains life up to 100 times longer than petroleum-based greases. Grease covers metal with a film that acts as a protecting seal against humid and salt conditions. Applications include fuel systems, couplings, plug valves, gate valves, missiles, fuel pumps, and flight refueling systems. Material is

WARNER'S NEW SPLINE DRIVE ARMATURE reduces brake and clutch maintenance on high-cycle applications

Heavy shock loads are no problem for Warner electric brakes and clutches—not with this new spline drive armature.

Impact is distributed evenly on multiple splines. Wear is all but eliminated, even on heavy-duty, high-cycle applications.

The female splined armature hub, made of dense Meehanite metal, is free to slide axially on the mating steel hub. This allows automatic take-up for face wear. A new one-piece autogap spring provides fast, snap-action release—speeds disengagement and prevents rubbing.

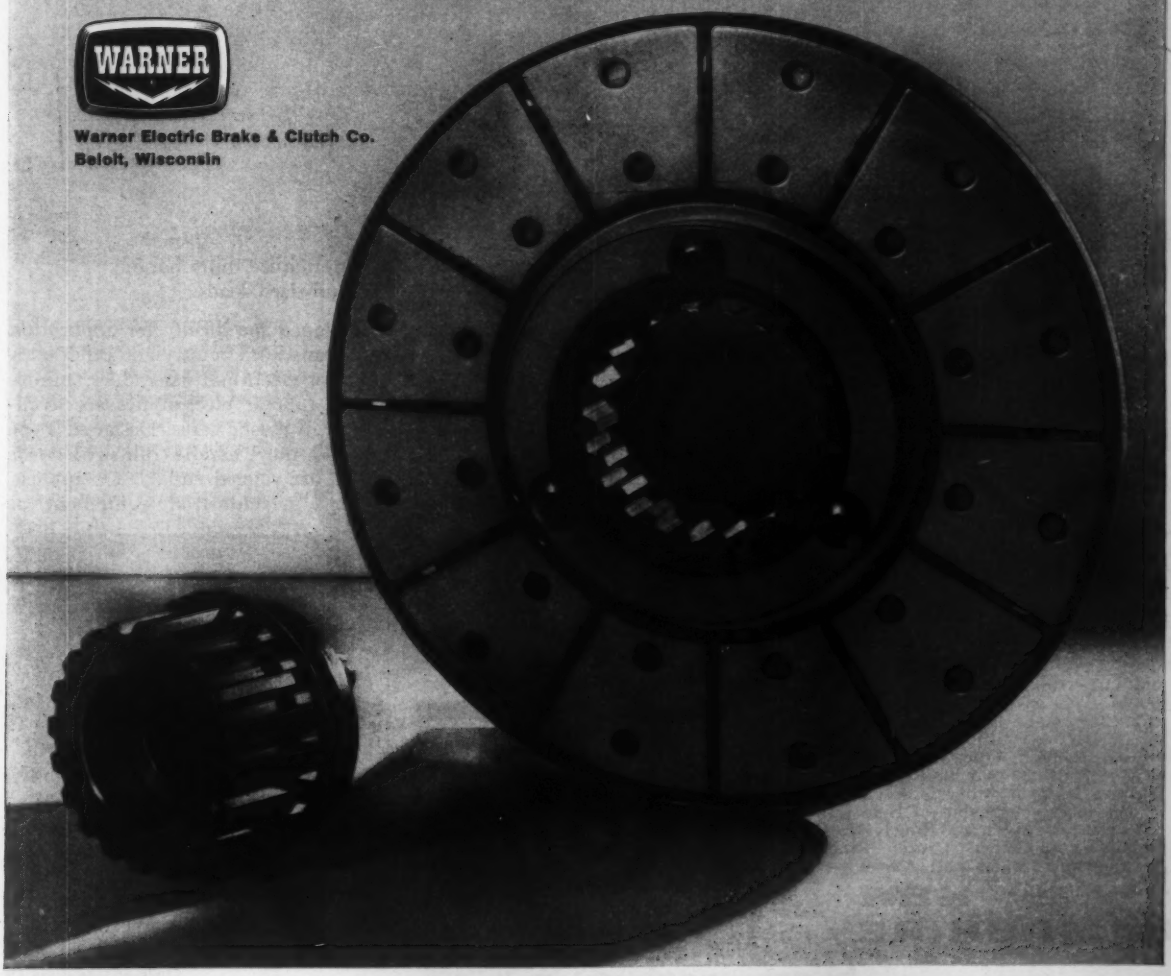
The beauty of Warner's new armature drive is its ease of installation. To align it, you just press the armature against the magnet face. There are no complex adjustments to make. Clearance is preset for initial installation—automatic from that point on.

Thus, for about the same installed cost, you can put a higher quality component on your machine drive—protect your customer against wear problems caused by rapid, continuous cycling of high torque loads.

Spline drive armatures are now available from stock for Models 825 to 1525 Warner electric brakes and clutches. For complete specifications, write for Bulletin P-68.

WARNER

Warner Electric Brake & Clutch Co.
Beloit, Wisconsin



BEARING ABSTRACTS

by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.

WHY CLASS ABEC 7 BEARINGS?

Improved Running Quality in critical applications is the reason why the Annular Bearing Engineers Committee of the Anti-Friction Bearing Manufacturers Association, Inc., has established Class 7 as the highest United States standard for manufacturing tolerances of miniature ball bearings. Originally available only on order . . . and at premium prices because of selection from ABEC 5 production runs . . . ABEC 7 bearings are now offered by New Hampshire Ball Bearings, Inc., as its minimum standard . . . at no extra charge.

An item-by-item comparison of ABEC 5 and ABEC 7 standards clearly shows how closer tolerances improve running quality.

(COMPARATIVE CHART)

RING		MEASUREMENT	TOLERANCES ABEC 5	TOLERANCES ABEC 7
Both	1.	Radial Runout (TIR) Max.	.0002"	.0002"*
Inner	2.	Side Runout with Bore	.0003"	.0001"
Outer	3.	O. D. Runout with Side	.0003"	.00015"
Both	4.	Parallelism of Sides	.0002"	.0001"
Inner	5.	Groove Parallelism with Sides	.0003"	.0001"
Outer	6.	Groove Parallelism with Sides	.0003"	.0002"
Inner	7.	Bore (I.D.)	+.0000" −.0002"	+.00000" −.00015"
Outer	8.	O.D.	+.0000" −.0002"	+.0000" −.0002"**
Both	9.	Width (Individual Rings)	+.000" −.005"	+.000" −.005"***

*ABEC 7 allows .0002" radial runout for outer ring. We hold it to .0001".
**We hold it to −.00015"
***We hold it to −.001"

Radial Runout . . . the sum of a ring's out-of-roundness and eccentricity . . . is functionally important. In critical high-speed applications, it affects balance and true running. In precise gear trains, it affects backlash and sometimes angular velocity ratio. In closely designed synchros and similar electrical equipment, it affects air gap control. Since most bearings operate with inner ring rotation, you'll notice that ABEC 7 cuts the ABEC 5 allowance in half . . . from .0002" max. to .0001". For the outer ring ABEC 7 makes no change from Class 5's .0002" max. However, modern race grinders work to a nominal zero runout and .0001" max. may usually be expected. Our inspection tolerance, therefore, is .0001". This gives outer-ring rotation applications the same advantages as for inner-ring rotation.

Perpendicularity of raceway planes to axis of rotation is a highly desirable feature. Its probability is determined by the interrelationship of Side Runout with Bore (Inner Ring), O. D. Runout with Sides (Outer Ring), parallelism of sides and groove parallelism with sides of both rings, when bearings are properly mounted and seated. If raceway planes are not perpendicular to the axis of rotation, stresses and torque peaks will be developed within the bearing because of this misalignment unless radial clearance and enlarged raceway curvature are sufficient to compensate. This effect may be observed in clamped, preloaded duplex bearings by shifting the relative position of the rings, reclamping and feel-testing.

Notice that the five perpendicularity features (2 through 6 in the chart) have much lower allowances in ABEC 7 than in ABEC 5. These differences in angular inaccuracy mean much in running quality as bearings become smaller. For example, non-parallelism of .0002" on a ⅜" O.D. (R 2 bearing) represents an angular error of about 2 minutes. But, on a 3/16 O.D. (R 1 bearing), the same allowance means 4 minutes of angular error. That's why ABEC 7 reduces allowances by one half or more. The importance of minimizing angular error is also reflected in the AFBMA tables of allowances, which are generally reduced within each class as size of bearing is reduced.

Envelope Tolerances (7, 8, and 9 in the chart) make little or no difference in running quality. The only ABEC change is from bore tolerance of plus 0, minus .0002 in Class 5 to minus .00015 in Class 7. This permits mounting bearings to a narrower spread of fits. Although ABEC 7 allows the same O.D. and width tolerances as for ABEC 5, we have reduced O.D. tolerance to plus zero, minus .00015" and, together with other manufacturers of instrument bearings, have reduced width tolerance to minus .001. The latter minimizes variation in axial spacing of assemblies.

Other Factors that affect running quality of bearings are not covered by ABEC standards. They include: truth of raceway geometry, surface finishes, retainer design and finish, radial and axial play and some ball qualities. These are discussed in our design handbook.

DESIGN HANDBOOK OFFERED FREE

You'll find this up-to-the-minute, authoritative 70-plus-page publication a great help in designing instruments or small electromechanical assemblies. Write to New Hampshire Ball Bearings, Inc., Peterborough 1, N. H.

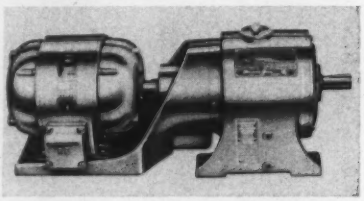
NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

available in 1 and 5-lb cans, and in drums to 400 lb. **Industrial Lubricants Div., Lehigh Chemical Co.,** Flatland Road, Chestertown, Md. C

Circle 803 on Page 19

Gear-Reducer Units

in ratings from ½ through 50 hp



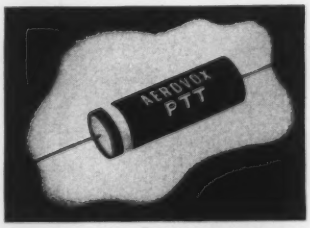
"All-motor" gear-reducer units provide gear reduction ratios from rated motor speeds down to 520 rpm through 9 rpm output shaft speeds. Reducers, available in ratings from ½ through 50 hp, are supplied in single, double, and triple reductions. Uses are found wherever machinery requires a low-speed, high-torque drive. **Reuland Electric Co.,** 3001 W. Mission Rd., Alhambra, Calif. L

Circle 804 on Page 19

Tubular Electrolytics

miniature units handle full-sized loads

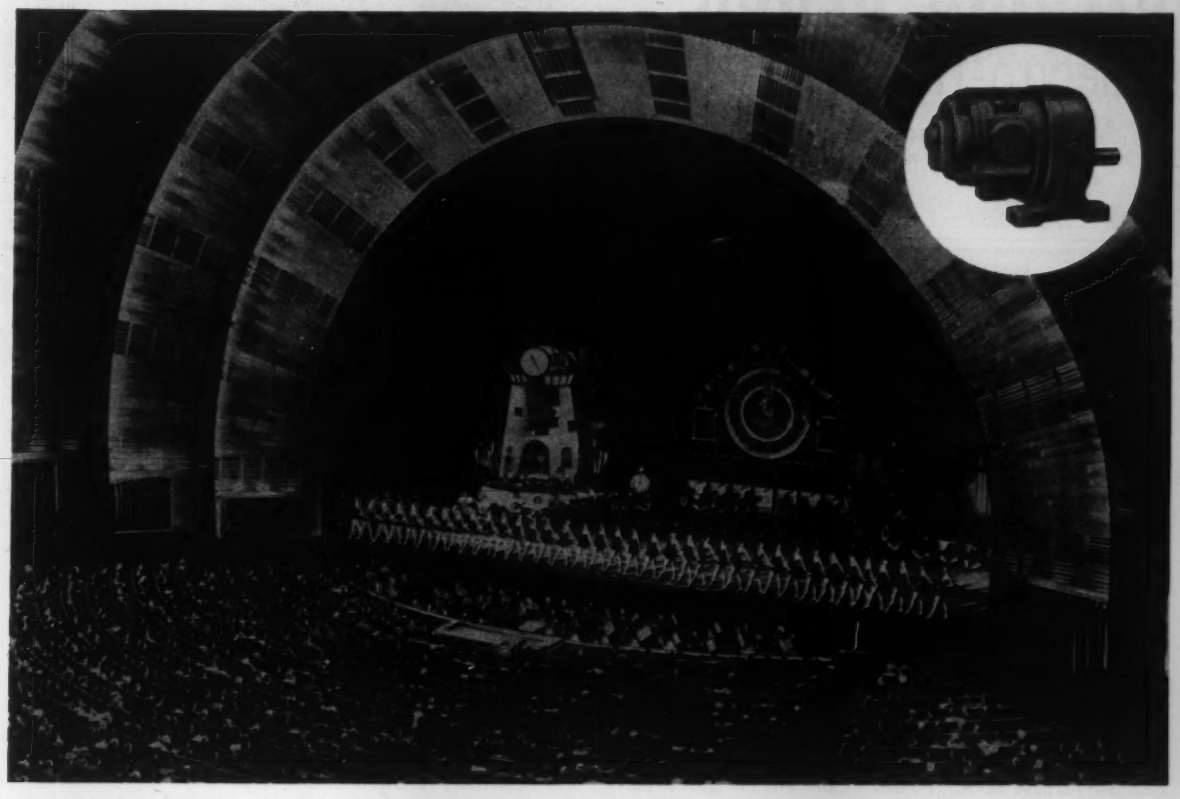
Designed specifically for application in transistor circuitry and other miniature electronic assemblies, miniature tubular electrolytics are available in plastic cases. Designed Type PTT, they handle full-sized loads and are rugged enough for applications in industrial equipment as



well as all limited-space assemblies. Units operate in temperature range of −30 to +65 C. They are available in a complete selection of capacitances at voltage ratings of 3, 6, 10, 12, 15, 25, and 50. **Aerovox Corp.,** 740 Belleville Ave., New Bedford, Mass. B

Circle 805 on Page 19

OUTSTANDING PERFORMANCE AT RADIO CITY MUSIC HALL... ANOTHER STERLING SLO-SPEED SUCCESS STORY!



To power the complex, controlled movements of its mammoth stage settings, Radio City Music Hall, the nation's largest theater, relies on Sterling Slo-Speed for crane and hoist duty electric power drives.

Mr. Peter Tozzi, Vice President of American Stage Equipment & Iron Works, Inc., who installed these Sterling Gear Motors, tells of their selection:

"After investigating a variety of methods for the effective control of these intricate stage settings, we decided on Sterling Slo-Speed gear motors.

"10 years of quiet, trouble-free operation have proved that Sterling Slo-Speed gear motors were the right choice. Their smooth and efficient performance has been outstanding."

Only STERLING SLO-SPEED Gear Motors provide these important advantages for efficient speed reduction:

- The unique offset gear construction eliminates wasted space. The more compact gear train design utilizes wider and larger diameter gears for greater strength and lower tooth pressure. The design of the gear case affords greater rigidity and strength.
- The tooth profile and helix angle of Sterling gears provide quiet operation and multiple-tooth contact with low thrust on bearings. Sterling helical gears, used in combination with heat-treated alloy steel pinions, insure maximum service life and trouble-free operation.
- Sterling positive oil seals keep oil in for maximum lubrication and leak-proof protection. Dirt and moisture are sealed out. Oil seals are impervious to chemical action of the lubricant.
- Sterling's oil sealing method and dip-splash lubrication permit universal mounting— vertically, *shaft up or down*, or in any horizontal position.

For additional information about the unmatched advantages of Sterling Slo-Speed Gear Motors for your application, please request a copy of our Bulletin 191.

STERLING
ELECTRIC MOTORS, Inc.

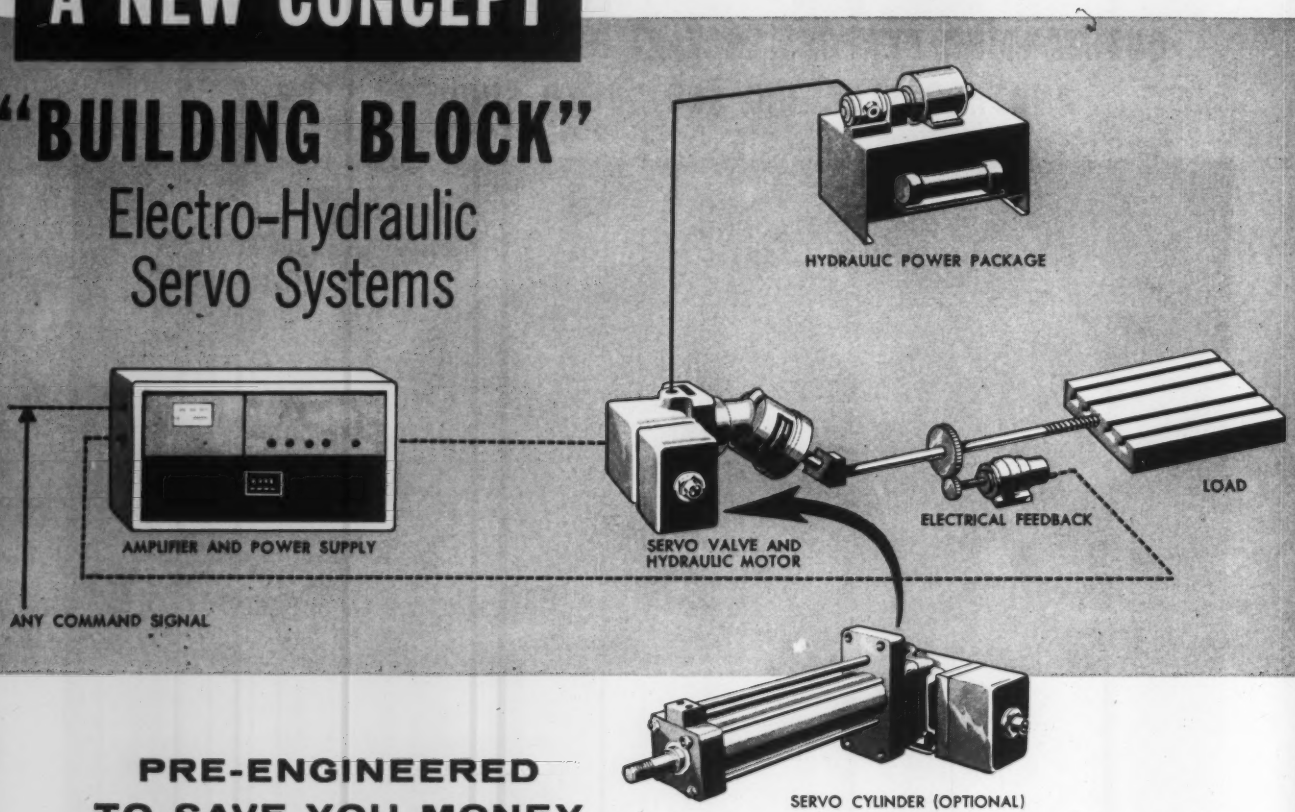
Offices and stocks in all principal cities. Over 400 distributors throughout the country to serve you.

5401 TELEGRAPH ROAD • LOS ANGELES 22, CALIFORNIA

Circle 609 on Page 19

A NEW CONCEPT

"BUILDING BLOCK"
Electro-Hydraulic Servo Systems



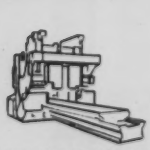
PRE-ENGINEERED TO SAVE YOU MONEY

Standard hydraulic and electrical components are now pre-engineered into a series of complete and dependable Electro-Hydraulic Servo Systems. Vickers has the most extensive line of individual "building block" components available for such systems. Inherent "trim flexibility" makes possible systems which will satisfy a very wide range of application . . . at only a fraction of the cost usually incurred in specially engineered systems. A very substantial saving in lead time is now possible.

Vickers "Building Block" Closed Loop Servo Systems have proved their merit on machine tools, fabricating machines and processing equipment. The amplifier is precisely matched to the servo valve torque motor. The work load requirement is continuously monitored by electrical feedback devices to insure that directions (command signals) are accurately followed at all times.

Positional accuracy of better than .001 is obtainable with a hydraulic motor and lead screw. In many position applications, cylinders can be used with similar accuracies. Velocity can be maintained within one or two rpm. In addition to position and velocity controls now in service, constant horsepower and constant tension systems soon will be available. Any command signal may be used with these systems . . . from a simple potentiometer to complete numerical control. For further information, ask for Engneering Bulletin No. 59-75.

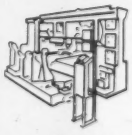
wide range of applications


CUTTING MACHINERY

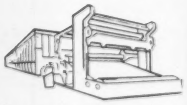
FOOD PROCESSING

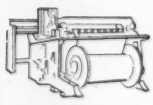
FORMING MACHINERY

TEST STANDS


FABRICATING

ANTENNA DRIVES


PAPER MACHINERY


TEXTILE MACHINERY

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: ATLANTA • CHICAGO* • CINCINNATI • CLEVELAND DETROIT* • GRAND RAPIDS • HOUSTON • INDIANAPOLIS • LOS ANGELES AREA (El Segundo)* • MILWAUKEE • NEW YORK AREA (Springfield, N.J.)* • PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) • ROCHESTER • ROCKFORD SAN FRANCISCO AREA (Berkeley) • SEATTLE* • ST. LOUIS • WORCESTER
Factories also in: Australia, England, Japan and Germany • In Canada: Vickers-Sperry of Canada, Ltd., Toronto*, Montreal and Vancouver
Field Service Headquarters Underlined. Whse. Stock & Repair Branches*.

8356

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 610 on Page 19

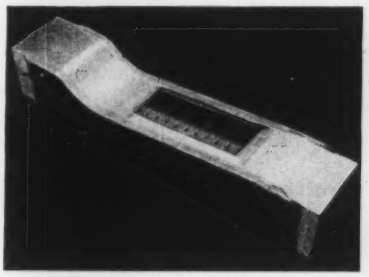
ENGINEERING DEPARTMENT

EQUIPMENT

Photostress Gage

is direct-reading, strain-sensitive device

PhotoStress Gage is a small, rectangular piece of plastic mirrored on one side, covered with polarizing material on the other, and incorporating a graduated scale. Contrasting color fringes are always visible along length of gage. When strain is applied along axis of gage, color fringes shift to a new position on scale. When unit is bonded



to a structure to which a load is applied, load strains metal which in turn strains gage. For every strain level, fringes in gage assume another position. Displacement of fringes is directly proportional to strain. Since gage is calibrated, strain is indicated by fringe position and is read directly from scale. Strain sensitivity is within 20 or 40 microinches per inch, depending on type of gage. Unit can be used either dynamically or statically, and can be applied on almost any material. **Tatnall Measuring Systems Co.**, P. O. Box 245, Phoenixville, Pa. E

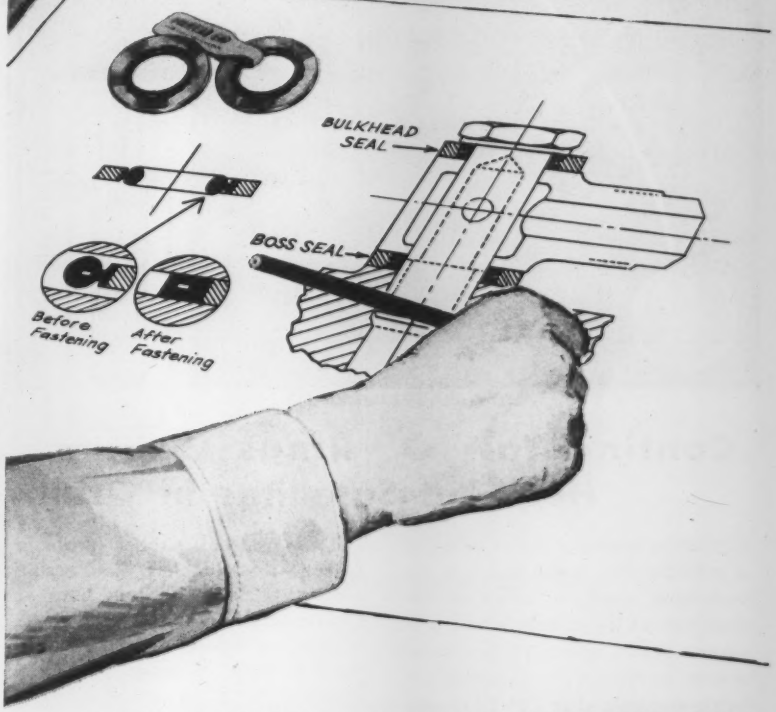
Circle 806 on Page 19

Socket Mounts

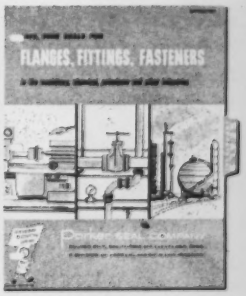
for use with circuit boards models 23 and 24

Standard socket mounts include seven and nine-pin miniatures, octals, and all other standard tube bases. They can also be obtained for transistors and other multilead

NOW YOU *CAN* USE BANJO FITTINGS IN YOUR DESIGNS!

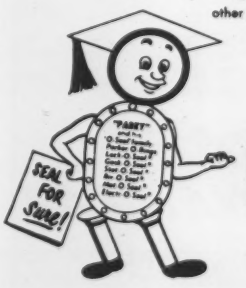


Some years ago, this famous space-saving fitting lost favor with engineers due to the difficulty of sealing them properly. But *now*, Banj-O-Seals* make the use of banjo fittings popular again! Banj-O-Seals* are a development of Parker Seal Company, using the famed one-piece Stat-O-Seal* design. They make it easy to seal "banjo" fittings . . . they are easy-to-install, easy to remove and *they provide no-leakage sealing*. Proof of the pudding? . . . Banj-O-Seals are retrofit on nearly every leading airline!



write for free catalog and literature.

Stat-O-Seals*, also seal bolts, studs and other fasteners . . . self-centering, re-useable, easy to install.

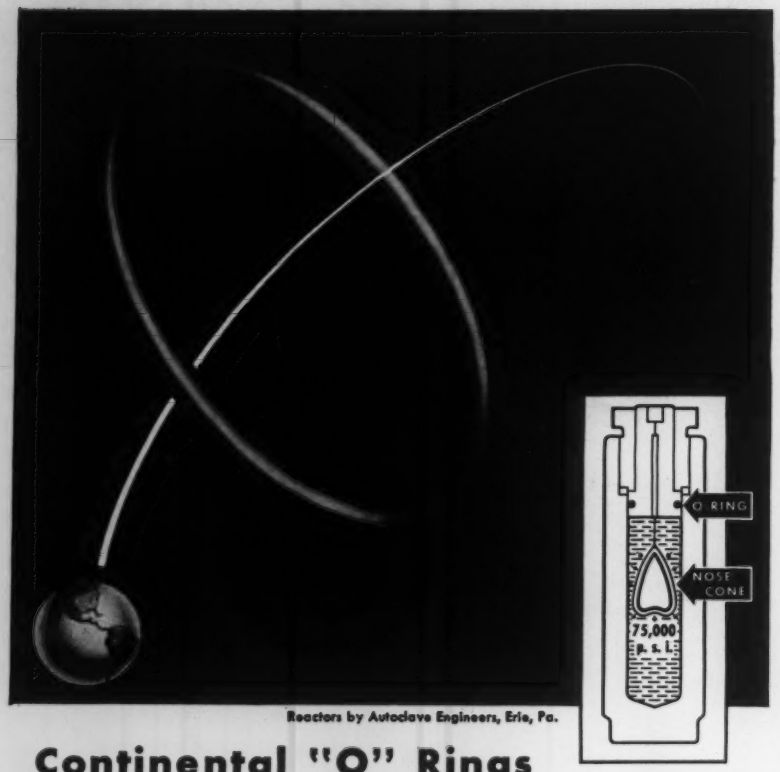


. . . another example of "seal-for-sure" designs by . . .

Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio
A DIVISION OF PARKER-HANNIFIN CORPORATION

* Trade Mark Registered

Circle 611 on Page 19



Reactors by Autoclave Engineers, Erie, Pa.

Continental "O" Rings Help Put Satellites in Orbit

Almost as dramatic as the thrust of a satellite into outer space is the technique used to fabricate the nose cone of the missile. These nose cones, made either of powdered metals or refractory materials, are being compacted in 12" I.D. pressure vessels under hydrostatic pressure of 75,000 P.S.I. *Imagine the problem involved in sealing a vessel against such terrific pressure!*

Yet *THAT* is the problem solved by this Continental "O" Ring. Obviously an ordinary "O" Ring would not do. The job called for a special compound with molecular formation so precise that separation or micro-leakage just could not occur. Continental developed the compound that meets this rigid test. What's more, the elasticity of the rubber refuses permanent set and thus permits re-use of the ring.

This unusual rubber problem typifies the complete engineering service available to you here at Continental. Whether you need molded or extruded rubber parts, consult with us *while your new products are still on the board.* Let us suggest how you might save both tooling and material costs—and get a better product for the job.

Hydrostatic Pressing (see diagram).

A technique for producing uniform compaction and grain structure to obtain super hardness and impact resistance in critical components. A steel forming-mandrel is coated with a refractory material, placed in a rubber bag and suspended in pressure vessel. Pressure is applied until required density is attained.

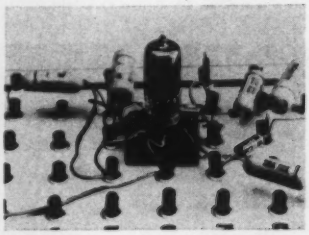
Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

Circle 612 on Page 19



components. Units consist of small plastic boards that fit directly over one or more elastic cores. Soldered leads attached to sockets can be inserted into nearby contact cells. Components or jumper wires are then connected to socket by inserting ends into same cells. Cells consist of gold-plated eyelets and elastic cores. When core is pulled upward, it stretches, allowing space for insertion of wires inside eyelet. When core is released, it pushes wires firmly against gold-plated surface, establishing a secure electrical contact. **Plastic Associates,** 185 Mountain Rd., Laguna Beach, Calif. L

Circle 807 on Page 19

Drafting Film

has extremely high transparency

Intended for use in all original pencil or ink applications, Cronaflex drafting film affords fine reproduction details. Extremely high transparency permits fast printing speed on blueprint and diazo machines. Fine matte surface is balanced to accept pencil lead over a wide range of hardness. Erasures can be made easily without removing matte finish or leaving ghost lines. Film has excellent dimensional stability under a range of climatic conditions. It is impervious to moisture, and can be cleaned readily with conventional drafting-room solvents. Film is available in cut sheets as well as rolls of any length. Maximum width is 44 in., and thickness is 0.004 in. **J. H. Weil Co.,** 1332 Cherry St., Philadelphia 7, Pa. E

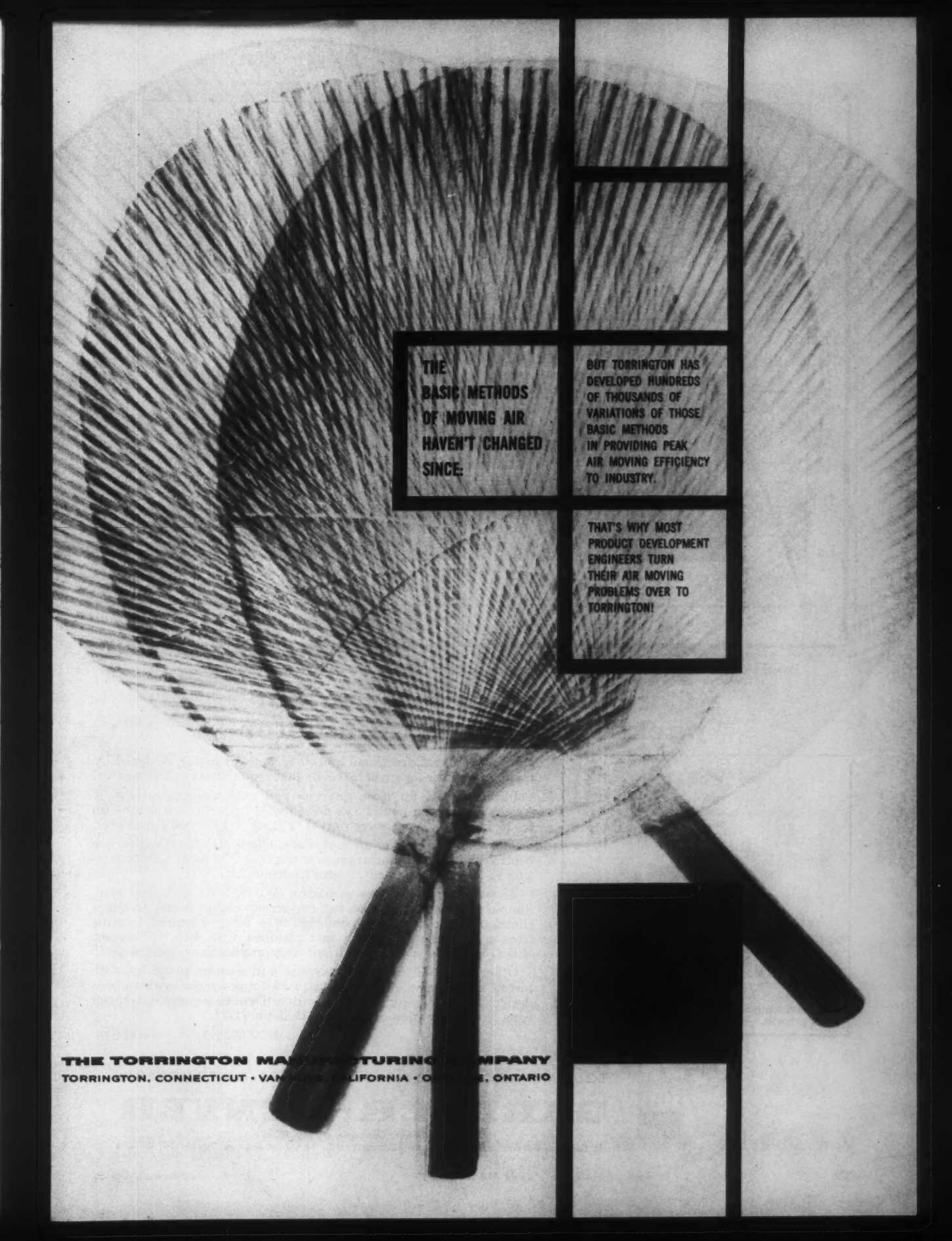
Circle 808 on Page 19

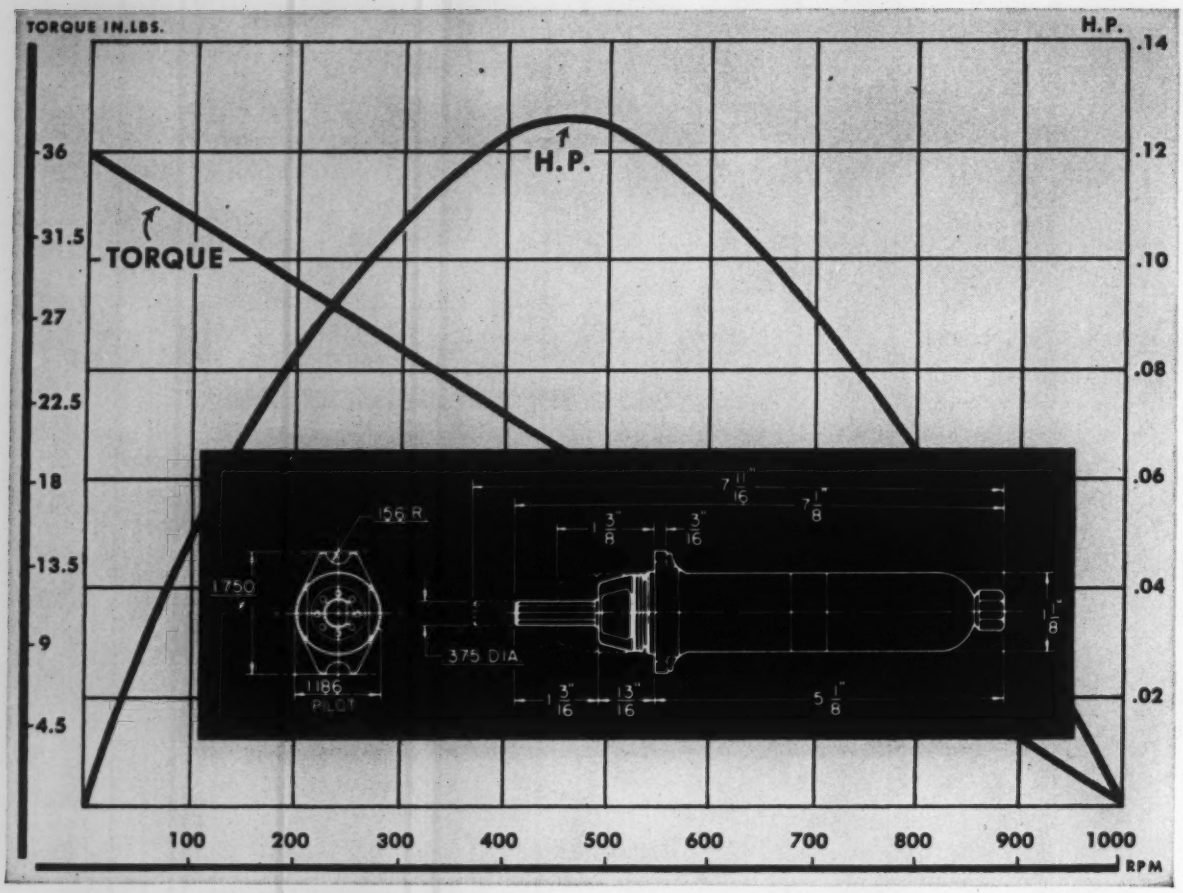
Small Computer

desk-size unit is transistorized

Sirius is a binary-coded decimal machine using transistorized logical

Circle 613 on Page 19→


THE BASIC METHODS OF MOVING AIR HAVEN'T CHANGED SINCE:
BUT TORRINGTON HAS DEVELOPED HUNDREDS OF THOUSANDS OF VARIATIONS OF THOSE BASIC METHODS IN PROVIDING PEAK AIR MOVING EFFICIENCY TO INDUSTRY.
THAT'S WHY MOST PRODUCT DEVELOPMENT ENGINEERS TURN THEIR AIR MOVING PROBLEMS OVER TO TORRINGTON!
THE TORRINGTON MA
TORRINGTON, CONNECTICUT • VA
ONTARIO



Power curve for this air motor shows 36-in.-lb. torque at low speed . . . max. power development of ⅛ hp.

Compact rotary air motor packs ⅛ hp in 1⅛″ diameter

WHEREVER IN THE WORLD

the products you design are put to work, your customers will find a convenient Gardner-Denver office with ample parts stocks on hand, and manned by factory-trained service specialists. At Gardner-Denver there's no substitute for men—our 100-year philosophy of growth.

Here's a compact, fractional hp rotary vane air motor, designed by Gardner-Denver for small hp needs that require heavy-duty service.

Ideally suited for close quarters and portable applications, it weighs less than a pound . . . develops ⅛ hp with stall torque up to 36 in.-lb. . . . measures only 7⅛″ long x 1⅛″ body diameter.

This Gardner-Denver air motor also offers variable speed-torque control . . . positive, instantaneous response . . . continuous operation . . . no spark hazard . . . can't burn out.

Three basic speeds are available: 20,000, 5000 and 1000 rpm. Simple plate-mounting with two cap screws makes it easy to adapt the motor to any setup. It's designed to be flange-mounted, locating from a 1 3/16″ diameter pilot and clamped with two ¼″ screws. Either continuous or intermittent-duty applications are practical.

Other rotary air motors are available in sizes up to 1.5 hp, with piston motors available to 16 hp. Put air power to work in *your* design. Contact your nearby Gardner-Denver representative for complete information or write for Bulletin 71-21.

GARDNER-DENVER Since 1859 — 100 1959 YEARS

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois
In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Circle 614 on Page 19

element and magnetostriction delay line memory. The desk-size unit weighs 560 lb and measures 7 x 3½ x 4 ft, including standard office desk. Desk provides operator's position but only top surface is used; drawers remain available for normal use. Computer is a small, relatively inexpensive, fast machine. Chief application is expected to be statistical analysis in industry, and as an ancillary machine for large computing installations. Input and output are by means of punched paper tape. Set of 100 keys can be used to operate unit and make entries directly into main memory. **Electronics Div., Ferranti Electric Inc.**, 95 Madison Ave., Hempstead, L. I., N. Y. D

Circle 809 on Page 19

Thermocouple Tubing

of spectrographically pure alumina

Thermocouple tubing produced from spectrographically pure alumina is available in sizes down to 0.03 in. OD. Material shows by spectrographic analysis a boron content of less than 8 parts per million, cadmium of less than 10 parts, and hafnium of less than 80 parts. All popular types and shapes of tubing are furnished, including both single and multibore. **Saxonburg Ceramics Inc.**, Saxonburg, Pa. F

Circle 810 on Page 19

The following two items appeared in our Aug. 6 and Aug. 20 issues, with photos transposed. Here they are—the right way.

Miniature Accelerometer

for −70 to +230 F temperature range

Model 2224 accelerometer is designed for applications where size and weight of instrument are critical. Subminiature model is ½ in. high

lightest weight/easiest installation/silent no hum operation

NEW HOKE

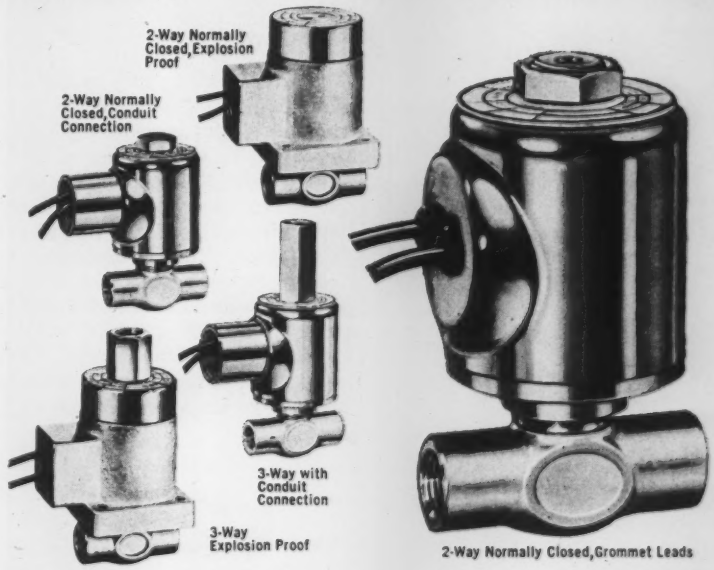
lowest temperature rise and power consumption

SOLENOID

stainless steel plunger design/silver ac shading coil

VALVES

smallest size/packless construction/operates any position



The lightest, smallest direct-acting solenoid valve available, featuring many innovations in design plus the usual, high-quality standards of all Hoke products. Two-way and three-way types (Series 90 and Series 95), with brass or stainless steel bodies are in production, in standard female connection sizes: ⅛" and ¼" as well as ¼" OD tube, 37° flare. Orifice sizes from 1/32" to ⅛". Mount in any position; a 360° rotatable coil housing permits connections from any angle. Choice of materials for valve discs and body gaskets. Variations in basic design to fit your needs. Competitively priced!

OK

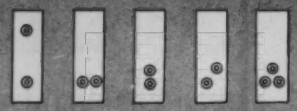
Complete specifications, ordering information, etc., are included in bulletin No. SV-559. Send for your copy.

Fluid Control Specialists

HOKE INCORPORATED, 91 PIERMONT RD., CRESSKILL, N. J.

Circle 615 on Page 19

Choice of Terminal Arrangements



for

VULCAN STRIP HEATERS

The terminal arrangements illustrated are just one indication of *Vulcan Versatility* in electric strip heaters. You also have a wide choice of standard seamless one-piece sheaths — steel for sheath temperature to 750°F, chromalloy to 1200°F; lengths 8" to 42½" (special — shorter or longer); wattage — 150 to 1500 watts (or higher); rugged non-oxidizing terminal posts. Heaters can also be formed into circles (one or two piece) in radius of 5" or more.

Vulcan Electric Strip Heaters are ideal for contact heating of dies, platens, molds, or any item with flat surfaces to which elements may be clamped; also as air heating sources for ovens, air ducts, dryers, etc.

Solve your hot problems with *Vulcan Versatility* in the application of electric heat. Send coupon for catalog and prices.

VULCAN ELECTRIC COMPANY
Danvers, Mass.

VULCAN ELECTRIC COMPANY
6 Holten Street, Danvers, Mass.

Please send me catalog and price information on Vulcan Electric Heaters.

Name & Title.....
Company.....
Street & No.....
City & State.....

Circle 616 on Page 19

and weighs 9 grams. Frequency response, ±5 per cent, is 2 to 6000 cps with amplitude linearity of 1

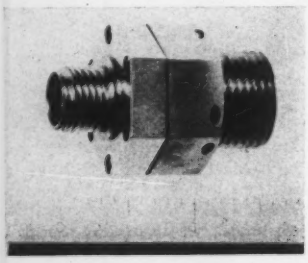
per cent and temperature range of −70 to +230 F. Insulated mounting stud provides complete isolation from ground loops. **Endevco Corp.**, 161 E. California Blvd., Pasadena, Calif. L

Circle 811 on Page 19

Miniature Transducer

for rocket engine test environments

Miniature pressure transducer, P285TC, is oil damped to withstand violent pressure transients generated in shock tubes or transmitted from firing chambers. High natural frequency of undamped miniature flush-diaphragm instruments is retained. Unit is developed for use in rocket engine test environments. Transducer measures pressures from 0-50 to 0-1000 psi with operational, environmental, and service life advantages of unbonded strain-gage transducers. Case length



is 49/64 in. and width between hexagonal sides is 1 in. Output is approximately 28 mv full scale, open circuit at 7 v ac or dc excitation. Nonlinearity and hysteresis are not more than ± 1 per cent of full scale. **Statham Instruments Inc.**, 12401 W. Olympic Blvd., Los Angeles 64, Calif. L

Circle 812 on Page 19

NEW!

COMPRESSION and EXTENSION SPRING TESTER FROM CHATILLON

The new Chatillon MST Spring Tester is COMPACT, EFFICIENT, ACCURATE (accurate to within one graduation)

FEATURES OF THE MST SPRING TESTER

- TESTS BOTH EXTENSION AND COMPRESSION SPRINGS
- ACCURATE TO WITHIN ONE GRADUATION
- COMPACT — INEXPENSIVE
- EASY TO USE — RACK & PINION DRIVE LOCKS LOAD AUTOMATICALLY AT ANY POINT
- 5% TARE ADJUSTMENT
- TEMPERATURE COMPENSATED CHATILLON TEMPRUF® SPRINGS
- AVAILABLE IN CAPACITIES RANGING FROM 5 lbs. x .02 lbs. to 500 lbs. x 1 lb.

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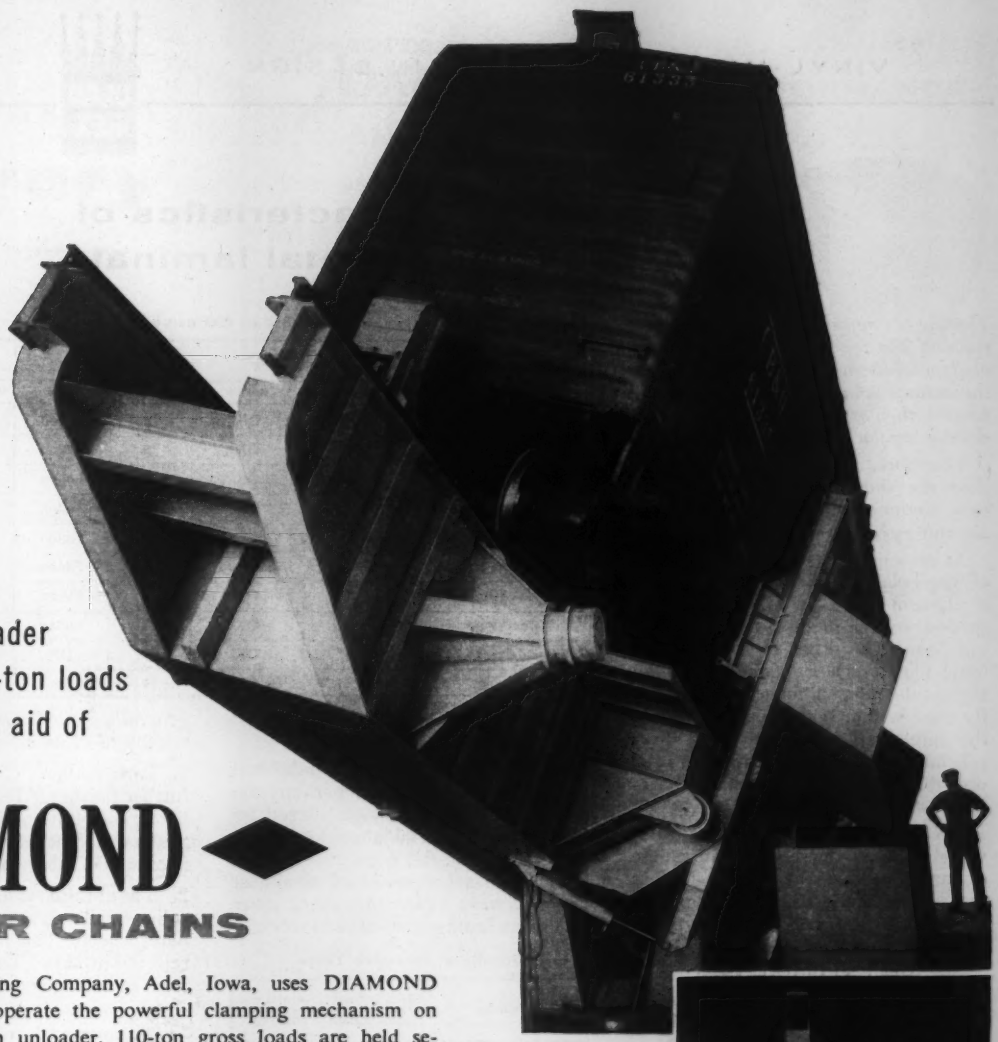
JOHN CHATILLON & SONS
85 CLIFF STREET, NEW YORK 38, N.Y.
Manufacturers of Scales, Force Measuring Instruments and Precision Springs Since 1835

Circle 617 on Page 19



Boxcar unloader handles 100-ton loads safely...with aid of dependable

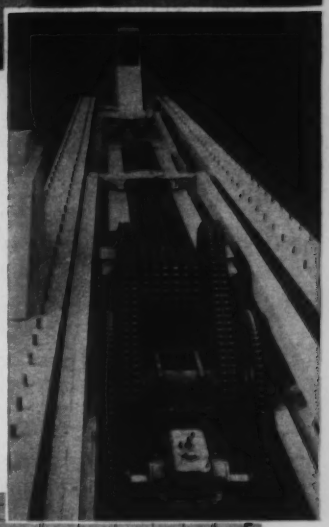
DIAMOND

ROLLER CHAINS

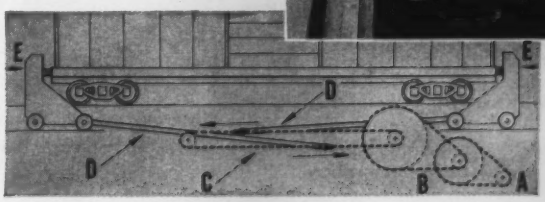
Straight Engineering Company, Adel, Iowa, uses DIAMOND Roller Chain to operate the powerful clamping mechanism on its hydraulic grain unloader. 110-ton gross loads are held securely while boxcar is tilted 18 degrees laterally and 37 degrees longitudinally in unloading cycles.

Like many other major equipment builders, Straight selected DIAMOND Roller Chain for its proven strength, dependability and long, trouble-free service under severe operating conditions. To solve problems of load, shock, fatigue . . . to insure reliable low-cost power transfer . . . specify DIAMOND as original and as replacement equipment wherever roller chain is used.

Your DIAMOND Distributor has all types and sizes of roller chain in stock. Look under "Chains" or "Chains, Roller" in the Yellow Pages of your phone book . . . or write to Diamond direct for complete catalog and name of your nearest distributor.



Single and double-strand DIAMOND Roller Chains, from power source (A) through speed reducing sprockets (B), operate six-strand endless DIAMOND Roller Chain (C)—(See diagram below). As chain (C) rotates, clamps connected to chain by linkage (D-D) are pulled tightly against ends of car at E-E and locked hydraulically.



DIAMOND CHAIN COMPANY, INC.

A Subsidiary of American Steel Foundries

Dept. 435 • 402 Kentucky Avenue, Indianapolis 4, Indiana

OFFICES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

DIAMOND ROLLER CHAINS

Circle 618 on Page 19

CLAD REX

The physical characteristics of CLAD-REX® vinyl-metal laminate

The use of vinyl-clad metals is growing rapidly. The type and variety of vinyl-clad metals is increasing also. Although the various vinyl-clads compete for attention, they are not alike. Nor do they deliver similar advantage.

Therefore, your vinyl-clad metals data file should be assembled with care. Know exactly what you are considering, when to use it, and how.

At present there are two basic types of vinyl-clad metal available. One is a plastisol which is roller coated or sprayed on the metal substrate in liquid form. The other is a calendered vinyl film which is laminated to the metal substrate. Various levels of quality exist within both areas. However, the laminated type generally offers substantially broader advantage to the user than the plastisol—primarily within the areas of styling.

Because the characteristics can obviously vary in degree with the gauge of metal and film as well as texture and pattern of film, the following tabular data must be considered as typical:

Results of Physical Tests

Characteristic	Properties of Film (8 Mil)	Properties of Laminate
Ultimate Tensile	4400 psi	Tensile of Supporting Metal
Ultimate Elongation	170%	Elongation of Supporting Metal
Tear Strength	910 lb. in.	Dependent on Metal Gauge
Bend Brittle, ¼" rod	—5° C.	—30° C.
Reverse Impact	Tears	120 in.—lbs.
Heat Deformation at 120° C. 2000 g. load	32%	30% (1 side)
Shrinkage 5 min. at 250° F.	4.6% with cal. grain 1.6% cross cal. grain	0.6% None

The corrosion resistance of Clad-Rex vinyl-metal laminate

The poly-vinyl chloride film used in Clad-Rex offers unusual resistance to chemicals. It will withstand acids, alkalis, alcohol, household detergents, salt water, industrial liquids, petroleum and corrosive atmospheres.

Results of Corrosive Tests

Agent	VINYL-METAL LAMINATE		PHENOLIC		ALKYD	
	Days Exp.	Result	Days Exp.	Result	Days Exp.	Result
10% Sulfuric Acid	17	OK	2	Failed	2	Failed
10% Nitric Acid	17	OK	2	Failed	2	Failed
10% Hydrochloric Acid	17	OK	2	Failed	2	Failed
10% Acetic Acid	17	OK	2	Failed	2	Failed
10% Lactic Acid	17	OK	17	Failed	2	Failed
10% Formaldehyde	17	Swelled	2	Failed	2	Failed
10% Caustic Potash	17	OK	3	Failed	2	Failed
Distilled Water	17	OK	17	Failed	2	Failed
Mineral Oil	17	OK	17	OK	17	OK
Ethanol	17	Sl. Shrink	17	OK	17	OK

The durability of Clad-Rex vinyl-metal laminate

Although the sales appeal of unlimited styling is a major factor, perhaps the most important advantage offered by Clad-Rex vinyl-metal laminates is their durability. Clad-Rex *is* practical to fabricate. It can be processed in almost as many ways as any *unfinished* sheet metal—including deep-drawing.

Results of Abrasive Tests

Coating	Mils Film Thick.	Total Revolutions	Revolutions Per Mil Film Thick.*
Vinyl-Metal Laminate	4.0	8,430	2,108
Vinyl-Metal Laminate	8.5	17,156	2,100
Phenolic	1.25	1,204	1,000
Urea-Alkyd	1.70	122	72
Vinyl Lacquer Coating	2.0 Ave.	703-954	351-477

*Abrasion resistance determined with a Taber Abrader using a CS-10 wheel.

The cost advantage of Clad-Rex vinyl-metal laminate

As a purchased material going into a users plant, vinyl-metal laminates cost more than unfinished or some other prefinished metals. *But, most important, end products made of Clad-Rex generally cost less!* The reasons are worthy of close examination:

1. Parts made of Clad-Rex require no further finishing. This means a savings in original equipment (including maintenance), finishing material, factory floor space, labor, handling, etc.

2. The abrasion resistance of Clad-Rex substantially reduces and often eliminates rejects. This means a savings in rejected products, handling and expensive reworking activities.

A source of engineering and manufacturing service for you

Clad-Rex interest in helping you extends into your own plant. A Clad-Rex Fabricating Engineer is provided to show your production people how easy it is to process Clad-Rex.

Furthermore, Clad-Rex operates a fully staffed and equipped research laboratory. Its facilities are devoted to customer service as well as improving Clad-Rex itself.

Write and describe your product. See how Clad-Rex can work its broad effect on industrial design, engineering and selection of pre-finished metals in your product.

VINYL-METAL LAMINATES BY **CLAD-REX** DIVISION OF SIMONIZ COMPANY

2113 Indiana Avenue • Chicago 16, Illinois

Telephone: VIctory 2-7272

5B

Circle 619 on Page 19

THE ENGINEER'S Library

Recent Books

Friction and Wear. *Edited by Robert Davies;* 191 *pages,* 6½ *by* 9½ *in., clothbound; published by Elsevier Publishing Co.; distributed by D. Van Nostrand Co. Inc.,* 120 *Alexander St., Princeton, N. J.;* $5.50 *per copy.*

Complete proceedings of the first annual General Motors Research Laboratories' symposium cover both experimental and theoretical research in friction and wear. Eight papers analyze problems involving metallurgy, solid state physics, surface chemistry, and mechanics. Subjects include a model for the mechanical wear process, seizure during boundary lubrication, solid friction, monomolecular lubricating films, and variable sliding friction. Discussions that followed the presentations are recorded.

The Diesel Engine. *By L. V. Armstrong and J. B. Hartman, professor and head, Dept. of Mechanical Engineering, Lehigh University;* 360 *pages,* 5⅜ *by* 8¼ *in., clothbound; published by The Macmillan Co.,* 60 *Fifth Ave., New York* 11, *N. Y.; available from* MACHINE DESIGN, $8.75 *per copy postpaid.*

Theory, basic design, and economics of diesel engines are presented. Discussion ranges from refining methods for the oil to horsepower output. Mechanics of combustion, fuel injection, inertia balancing, torsional vibration, heat dissipation, efficiency, lubrication, supercharging, and speed control are covered. A design project follows the text to help explain how and why an engine acquires its final physical form.

How To Invent. *By Forest E. Gilmore;* 89 *pages,* 5 *by* 7⅜ *in., clothbound; published by and available from Gulf Publishing Co., Houston* 1, *Texas;* $2.50 *per copy.*

Fundamentals of the inventive process and techniques used by suc-

QUALITY TOKHEIM BUILDS PERFORMANCE IN . . . AND MAINTENANCE OUT . . .

IN NEW "MIRACLE METER" WITH

RULON® CUP PACKING . . . AND 9 OTHER RULON PARTS

TOKHEIM CORP. of Fort Wayne, Ind., leading manufacturer of gasoline pumps, needed a tough material for the cup packing of their new meter's plunger-assembly. Only Dixon's Rulon (reinforced Teflon) had the right combination of chemical *and* physical characteristics to withstand attack from all types of gasoline additives, and *also* stand up under the mechanical stress and wear of millions of plunger cycles. As a result of rulon's performance, it is used in 9 other places as shaft seals, thrust washers and sleeve bearings.

- **RULON resists deformation** — hugs cylinder walls, prevents leakage, maintains meter accuracy.
- **RULON reduces drag**—low coefficient of friction insures smooth operation—even in non-lubricating media (gasoline).
- **RULON wears longer** — tougher than Teflon, Rulon cuts costly maintenance . . . requires no lubrication.
- **RULON is completely inert** — doesn't change properties or swell in presence of liquids.

Look at your designs with RULON in mind. If it's a bushing, bearing, cam, wear strip, or insulator, chances are the combination of the correct RULON formulation plus DIXON's manufacturing capabilities can produce the exact component you need. *One of Dixon's many modifications of DuPont TFE Teflon.

For engineering data sheet 129-8, write . . .

Dixon **DIXON CORPORATION**
Bristol, Rhode Island

Check these outstanding properties of **RULON**

- Resistance to wear: 500 times Teflon
- Low coefficient of friction: 0.10-0.24
- Wide temperature range: −300° to +500°F
- Excellent electrical properties: Resistivity 10^{15}, dielectric constant 2.6, dissipation factor .002
- Chemically inert — Zero water absorption — Weather resistant
- Low coefficient of expansion: 3.3×10^{-5} (½ that of Teflon)
- Low deformation under load: ½ that of Teflon

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Ultimate Elongation	170%	Elongation of Supporting Metal
Tear Strength	910 lb. in.	Dependent on Metal Gauge
Bend Brittle, ¼" rod	—5° C.	—30° C.
Reverse Impact	Tears	120 in.—lbs.
Heat Deformation at 120° C. 2000 g. load	32%	30% (1 side)
Shrinkage 5 min. at 250° F.	4.6% with cal. grain	0.6%
	1.6% cross cal. grain	None

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10% Acetic Acid	17	OK	2	Failed	2	Failed
10% Lactic Acid	17	OK	17	Failed	2	Failed
10% Formaldehyde	17	Swelled	2	Failed	2	Failed
10% Caustic Potash	17	OK	3	Failed	2	Failed
Distilled Water	17	OK	17	Failed	2	Failed
Mineral Oil	17	OK	17	OK	17	OK
Ethanol	17	Sl. Shrink	17	OK	17	OK

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Coating	Mils Film Thick	Total Revolutions	Revolutions Per Mil Film Thick.*
Vinyl-Metal Laminate	4.0	8,430	2,108
Vinyl-Metal Laminate	8.5	17,156	2,100
Phenolic	1.25	1,204	1,000
Urea-Alkyd	1.70	122	72
Vinyl Lacquer Coating	2.0 Ave.	703-954	351-477

*Abrasion resistance determined with a Taber Abrader using a CS-10 wheel.

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Circle 619 on Page 19

THE ENGINEER'S Library

Recent Books

Friction and Wear. *Edited by Robert Davies; 191 pages, 6½ by 9½ in., clothbound; published by Elsevier Publishing Co.; distributed by D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; $5.50 per copy.*

Complete proceedings of the first annual General Motors Research Laboratories' symposium cover both experimental and theoretical research in friction and wear. Eight papers analyze problems involving metallurgy, solid state physics, surface chemistry, and mechanics. Subjects include a model for the mechanical wear process, seizure during boundary lubrication, solid friction, monomolecular lubricating films, and variable sliding friction. Discussions that followed the presentations are recorded.

The Diesel Engine. *By L. V. Armstrong and J. B. Hartman, professor and head, Dept. of Mechanical Engineering, Lehigh University; 360 pages, 5⅜ by 8¼ in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$8.75 per copy postpaid.*

Theory, basic design, and economics of diesel engines are presented. Discussion ranges from refining methods for the oil to horsepower output. Mechanics of combustion, fuel injection, inertia balancing, torsional vibration, heat dissipation, efficiency, lubrication, supercharging, and speed control are covered. A design project follows the text to help explain how and why an engine acquires its final physical form.

How To Invent. *By Forest E. Gilmore; 89 pages, 5 by 7⅞ in., clothbound; published by and available from Gulf Publishing Co., Houston 1, Texas; $2.50 per copy.*

Fundamentals of the inventive process and techniques used by suc-

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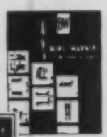

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cessful inventors are discussed. Suggestions are given on how best to use creative thinking, intuition, and imagination. Preparation for inventing, step-by-step methods, and a personal system for the process are recommended tools. An introduction to patent laws provides background information for the inventor.

New Standards

American Standard, ASA B1.10-1958, Unified Miniature Screw Threads. 18 *pages, 8½ by 11 in., paperbound, stapled; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $1.50 per copy.*

Fourteen standard screw-thread sizes with one standard design are established. Diameter range covered is from 0.30 to 1.40 mm, or 0.0118 to 0.0551 in. This series supplements the Unified and American Series beginning at 0.060 in. with number 0 of the machine-screw series.

A 60-degree thread angle and a coefficient of 0.52 for thread height were adopted. Tolerances have also been established. This series is substantially in agreement with Recommendation 68 of International Organization for Standardization and with agreements of the American-British-Canadian Conference on Unification of Engineering Standards of 1955.

Manufacturers' Publications

RCA Semiconductor Products. 39 *pages, 8⅜ by 10⅞ in., paperbound, stapled; published by and available from Commercial Engineering, Semiconductor and Materials Div., RCA, Somerville, N. J.; $0.30 per copy.*

This new edition gives maximum ratings, typical operation, characteristics, and outline dimensions for RCA germanium and silicon transistors and silicon rectifiers. Included are a section on transistor theory, an interchangeability directory listing over 1100 type designations of 29 different manufacturers, and a section on circuits containing 37 schematic diagrams that illustrate the more important applications.

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Professional Viewpoints

. . . the metrological dilemma . . .

Our editorial in the June 25 issue, on the subject of switching from the English system of measurement to the metric, prompted a number of readers to share their opinions, pro and con, on the subject. Here's how some of them feel about it.

To the Editor:

From a historical point of view it would appear that the English system of measurement should have prevailed. After all, the Industrial Revolution, which brought with it mass production and carefully controlled repetitive measurements, received its greatest impetus in England and its greatest expansion in this country.

But, the proposal is to adopt the metric system.

Abandoning the English system would be shamefully expensive, in both money and training. Millions of dollars are invested in the tools, measuring instruments, and drawings which are the backbone of our nation's productiveness; hundreds of thousands of engineers, draftsmen, mechanics, inspectors, and students have been trained, are experienced, and possess infinite facility with the use of these items.

Further, if we change to the metric system of dimensioning, should we not also adopt the International metric standards for tolerances, allowances, and fits? Will not all our screw threads, gears, prefabricated parts, items such as pipe, tubing, valves, and fittings change to metric standard sizes? Must we not retrain everyone to use first-angle projection for drawings, since this is the prevalent projection in metric drawings?

I do not, of course, intend to denigrate the metric system of measurements, or even to imply that this system is basically inferior to the English system. In fact, in working during World War II on conversion of metric drawings, primarily German and French, to English language standards and units, I found a certain classic simplicity in the system of dimensioning which could not be approached by the clumsy fractional dimensions of the English drawing. Interestingly enough, some of this simplicity would give deep satisfaction to the most *avant-garde* of functional drafting advocates. Such items as omission of cross-hatching and elimination of arrowheads were evident in drawings of the pre-World War II era.

It is possible that the big pressure for adoption of the metric system as far as plan work is concerned really stems from certain of its superior aspects. The metric dimension, whose basic unit is the millimeter, is a simple whole number. It is clear, neat, not easily mistaken for anything but what it is—a dimension number. Dimension sizes are readily added, subtracted, divided, or multiplied with minimum chances for error in arithmetic or interpretation. There is also a direct and appealing relationship between the decimal scale

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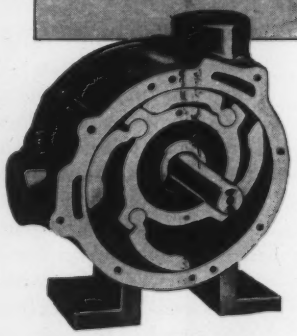

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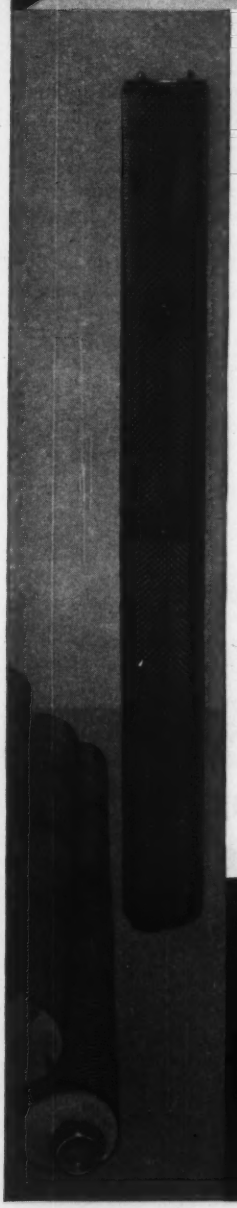

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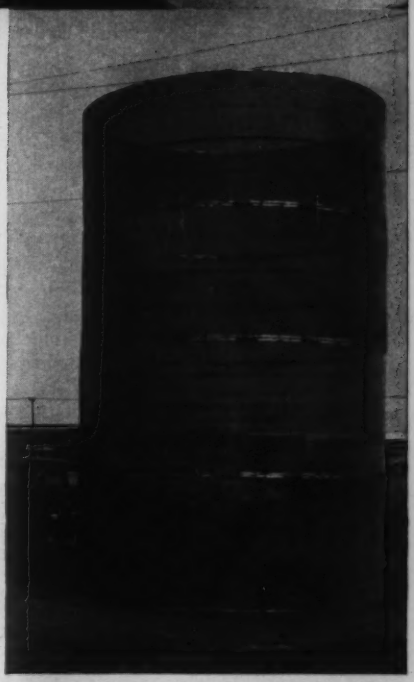

of the metric system and the anatomical scale of our ten toes and ten fingers. This helps us, in our dullest moments, to calculate unerringly and swiftly the dimensions of the most complicated configurations.

It is then this simplicity of dimensioning which appears to give the metric system its greatest advantage and which one suspects generates its greatest appeal to the scientifically minded segment of the technical community.

If this is the case, then there is no reason for abandoning the English system. We need only eliminate the fractional system of dimensioning and apply the best features of metric dimension to English drawing.

There is actually nothing novel in the use of single numbers and decimal dimensions in the English drawing system. The American Drafting Standard Manual for drawings recognizes, as an alternate procedure to fractional dimensioning, use of inches and decimal of inches to two places for noncritical dimensions. This certainly simplifies the drawing and gives it a metric appearance and neatness. It does require familiarity with the decimal scales and carries with it the classical danger of misplacing the decimal point.

There is still another possibility which gives an English drawing the nearest approach to and appearance of a metric drawing. I came across this possibility in the course of attempting, with consistent failure, to translate and transpose some Greek drawings to English units. These drawings appeared to be metric. The whole number of the millimeter unit were evident everywhere, but somehow dimensions would just not jibe; correlation could not be obtained. It was finally discovered that the basic unit was English, and this unit was 1/64 in. Thus a dimension of 1 in. was 64, 10 in. were 640, 1½ in. were 96, etc.

The system proved very neat, consistent, and simple to apply. It enjoyed all the advantages of the metric system without the disadvantages engendered by discarding the basic English system. It retained the basic tools, instruments, and measuring devices of the English system, but did not reject the inch and decimal of an inch for closely controlled measurements. In this respect, therefore, it was not inconsistent with existing standards of decimal tolerances and allowances. The drawings looked, worked, and checked as if metric, but were actually English to the core.

The 1/64 in. as a basic unit has the advantage of being the smallest unit size that can be comfortably distinguished on an ordinary scale without magnification or vernier attachments. It, therefore, lends itself more readily to the field of modern closely controlled dimensioning than the much coarser millimeter unit. It is also superior to the decimal 0.01 in., which is too fine a dimension for the average naked eye. It is, in other words, a good practical measurement compromise between the too-large millimeter scale and the too-small decimal inch scale. Furthermore, close tolerances can still be depicted on drawings as decimal parts of an inch since the inch is still the ultimate base of measurement.

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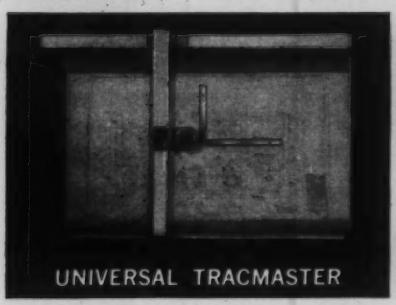
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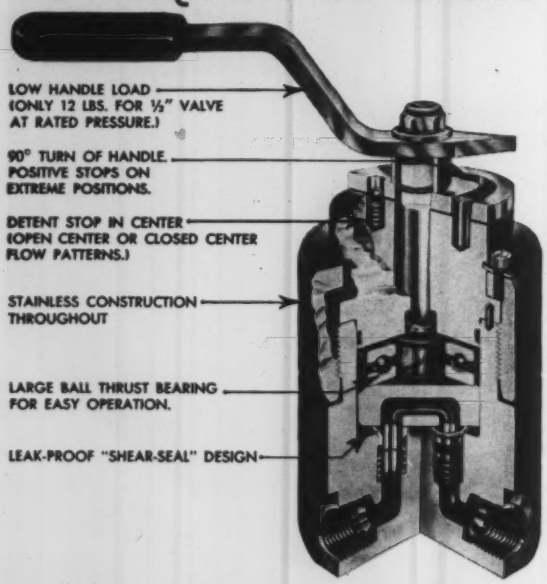

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

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or Angstrom might go far towards making this unit palatable to the engineering expert, the engineering scientist, the engineering pedagogue.

There is no particular reason why both metric and English dimensioning cannot coexist successfully as heretofore. The English system can be improved by eliminating the fractional dimension and changing to one of the simpler systems of notation.

—Arnold Buchsbaum
Valley Stream, N. Y.

To the Editor:

This English system of measurements of ours has been one of my pet peeves for years. I firmly believe our country's engineers would be taking a real step towards international co-operation in all fields if we would adopt the metric system.

The system suggested by F. W. Hough, Chairman of the American Geophysical Union Committee studying the question, has my vote as the most sensible approach. This would set the effective date of the change many years away. He suggests 33 years—17 would seem to me a better figure.

—Joe McCarthy
Jackson, Mich.

To the Editor:

I think we can speak with some authority, since we are the oldest precision manufacturers in the South and have had to build up a business with all kinds of labor.

There is no doubt that the shift from the American inch to the decimal system must come. We have found that to the average inexperienced person the decimal system is much easier to comprehend. We also find that, when we diffuse foreign-made machinery into our plant, the acceptance is overwhelming.

The change may have to come as a crash program, but the quicker it comes the better.

—Edward A. Brass
B & B Engineering Corp.
Norwood, La.

To the Editor:

To be sure, I am convinced, and not only because I am French, that the metric system has a great advantage over yours, because it is (a) decimalized and (b) homogenous, the surface or volume unit being the square or cube of the length unit, and so on.

Some day you will get tired of having 12 inches in a foot, 3 feet in a yard, 220 yards in a furlong, and 8 furlongs in a mile, not to speak of drams, pints, rods, ounces, quarts, acres, pounds, stones, gallons (imperial or not?), hogshead, bushels, hundredweights, tons (short or long?), and so on, related between themselves through awkward figures.

So long as you agree to change your system, why should you stay halfway and shift to a decimalized inch or foot-based system, instead of the metric? Some of your industries employ it. Why should you endeavor to make things more difficult than is strictly necessary?

—Peter E. Bezier
Regie Nationale des Usines Renault
Billancourt, Seine, France

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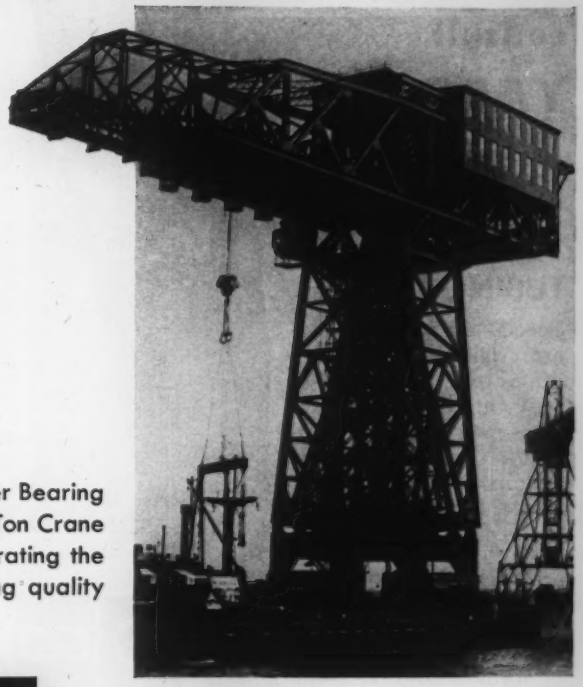

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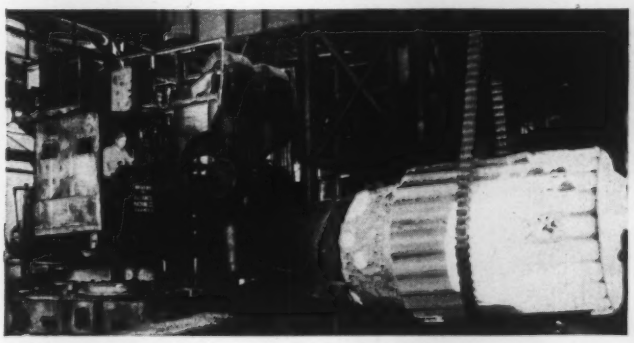

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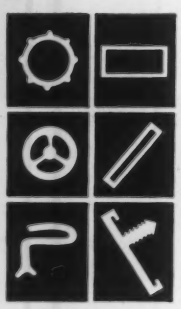

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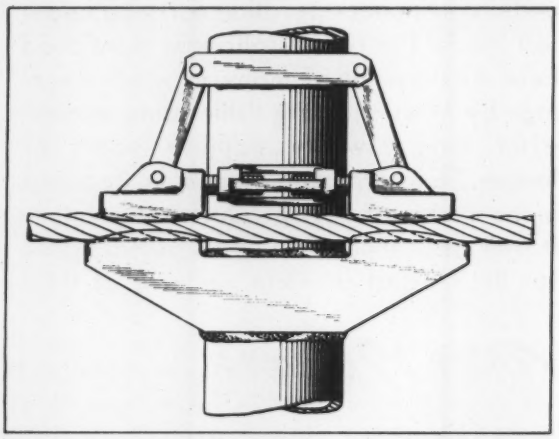

easily. Two members of the linkage are gripping shoes, and another is a turnbuckle. The shoes are drawn toward each other to increase gripping force. *Patent 2,897,564 assigned to Goodman Mfg. Co., Chicago, by James W. Hardy.*

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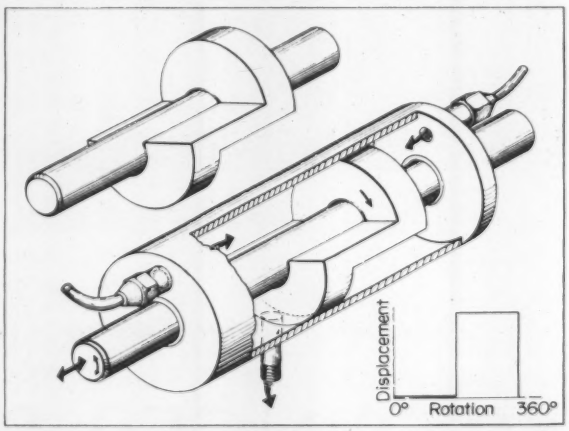

sensing piston. The piston, fixed to an axial shaft, is two half discs, spaced by an integral flat portion parallel to the shaft axis. Each piston half is sufficiently thick to cover an exhaust port. In a condition of rest, pressure inputs at opposite ends of the cylinder are

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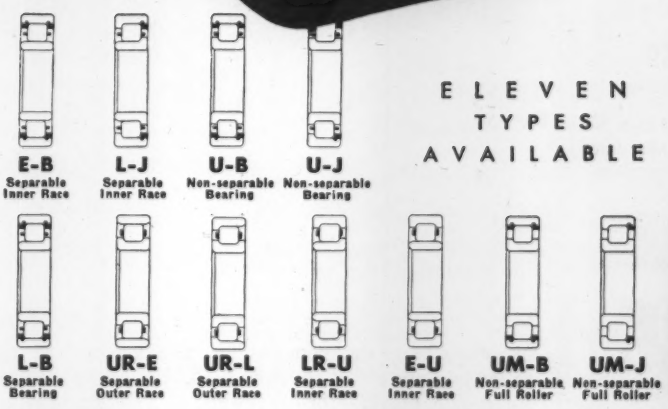
Tru-Rol Bearings provide above-commercial-grade efficiency . . . at worthwhile savings in cost. Internal clearances are closely controlled. Rollers are equally spaced to eliminate out-of-balance vibration. Each roller is crowned to distribute the load evenly along the full length of the roller. Eleven types available in single and double width bearings, in stamped steel retainer, segmented retainer or full roller construction.



ELEVEN TYPES AVAILABLE

Ask your nearby Rollway Service Engineer to detail the quality you *should be getting* in your "commercial grade" bearings. Or write for the Rollway Tru-Rol catalog showing the full line, and capacity and size ranges. ROLLWAY BEARING COMPANY, INC., Syracuse, N. Y.

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COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

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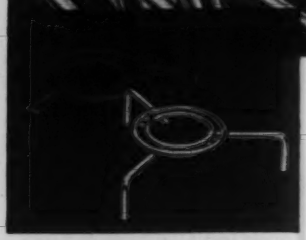
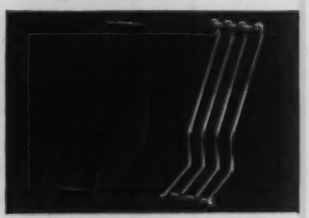


Wire motor mount cut costs, absorbed vibration, reduced weight.

Wire/strip paddle arm for cleaning unit reduced costs 70%; ended noise problem.



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Wire and wire/strip components improve the quality, efficiency and appearance of finished products.

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Wire and wire/strip components save on tooling, machining, and materials.

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Wire and wire/strip are strong and light; welds are stronger than parts joined.

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Send now for our Wire/Strip component design package. New handbook describes complete production facilities for fabricating wire forms, welded wire and strip assemblies, light stampings and staples.

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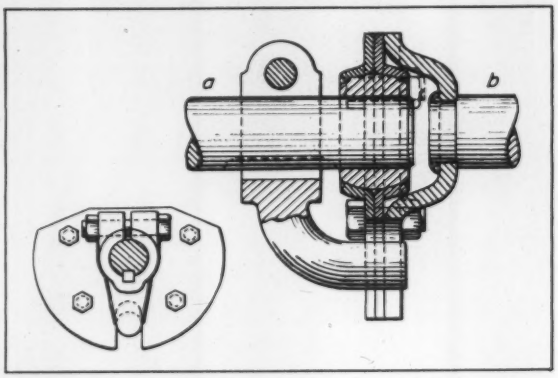
AND COMPANY
65 CLINTON STREET, BINGHAMTON, NEW YORK

equal, and the exhaust port is covered. Rotation of the shaft exposes the exhaust. A resultant pressure differential causes the other piston half to move axially and cover the exhaust. Translatory motion of the shaft is like cam action. *Patent,* 2,898,890 *assigned to International Business Machines Corp., New York, by John J. Lynott.*

Misalignment-Compensating Vibration Barrier

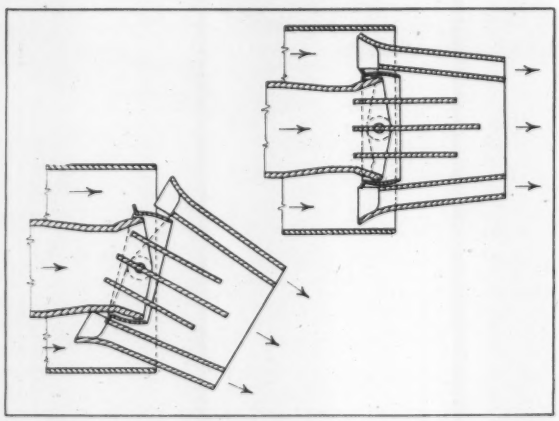
A clutch control shaft *a* and a clutch release shaft *b* are joined by a mechanism which fails to transfer certain vibrations from *b* to *a*. An L-shaped arm is fixed on *a* and engaged in a slot in a plate fixed on *b*. With



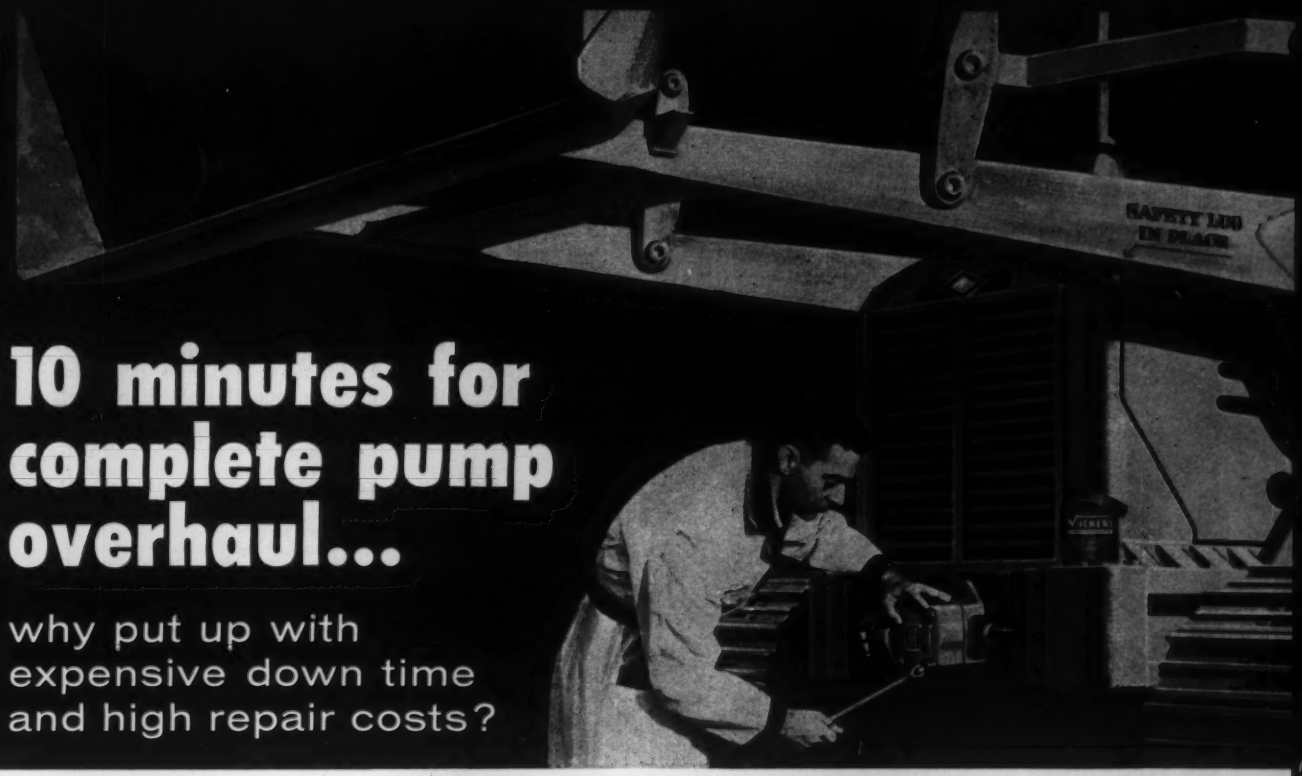
this kind of engagement, vibrations which are small axial movements of *b* cannot be transmitted to *a*. Also in this assembly, a semispherical member and its housing compensate for misalignment between the two shafts. *Patent* 2,897,661 *assigned to International Harvester Co., Chicago, by Joseph A. Hausmann.*

Uniform-Flow Adjustable-Direction Nozzle

Streams of two different gaseous mixtures, one within the other, are directed by an adjustable nozzle with-



out disturbing the composition and velocity of the center mixture across the flow path. Baffles fixed inside the nozzle provide this performance. Factors directly affecting performance are the distances between ad-



10 minutes for complete pump overhaul...

why put up with expensive down time and high repair costs?

on the spot
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"High Performance" Pumps*
keeps your jobs on schedule
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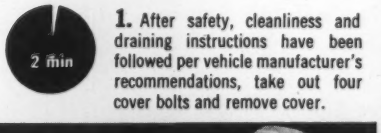
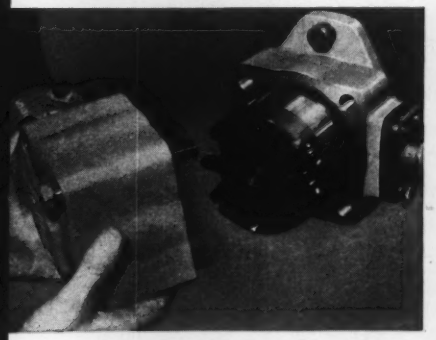
Without removing the pump from the vehicle, and without disconnecting hydraulic lines, the new Vickers "High Performance" pump can be completely overhauled by simply inserting a new pumping cartridge. The pumping cartridge contains all wearing parts in one replaceable unit and results in new pump performance. Write for Bulletin No. M5108 for performance characteristics.

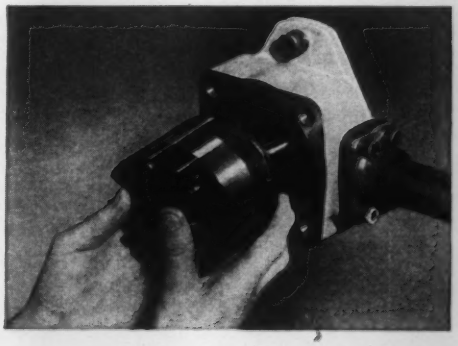


1. After safety, cleanliness and draining instructions have been followed per vehicle manufacturer's recommendations, take out four cover bolts and remove cover.

2. Take out old pump cartridge and insert new one. The cartridge includes cam ring, rotor, vanes, etc. —all parts in one assembly.

3. Replace cover and you have the equivalent of a new pump ready for long, trouble-free service.





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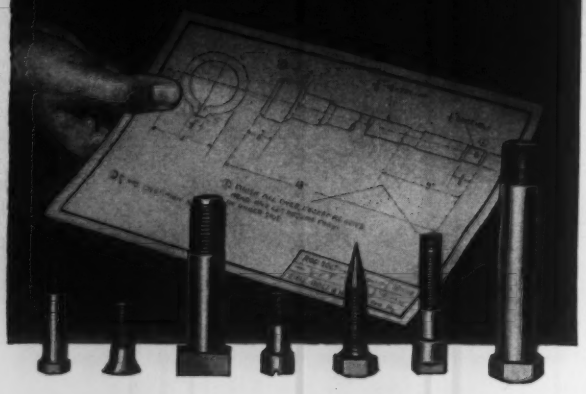
SPECIFICATIONS
TO SPECIALISTS . . .



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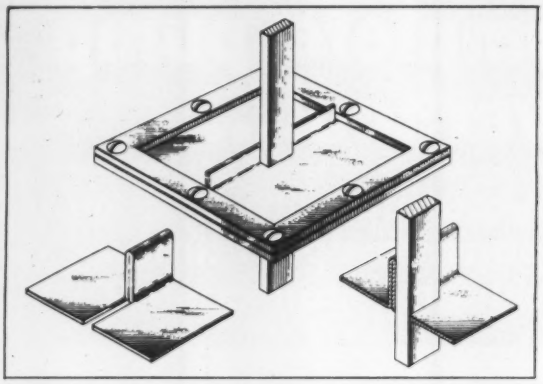
jacent baffles and the penetration of the baffles into the stationary source pipe. *Patent* 2,895,435 *assigned to Combustion Engineering Inc., New York, by Alexander Bogot and Virginius Z. Caracristi.*

Combined Flexible Seal and Pivot

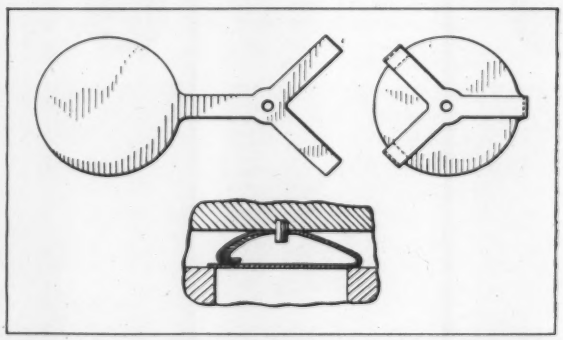
Substantially no friction and a low spring gradient are characteristics of a combined seal and pivot assembly. A functional member is a flexible diaphragm



clamped at its edges and crimped through its center. Relatively rigid, the crimp provides an axis of rotation. A beam, passing through the diaphragm and fixed to the crimp, is a contact member between pressure chambers. Beam displacement is determined by flexure of the diaphragm. *Patent* 2,897,678 *assigned to Minneapolis-Honeywell Regulator Co., Minneapolis, by Robert J. Wagner.*

One-Piece Spring Valve

Stamped from resilient material, a one-piece valve consists of a circular flap and spring fingers bent back



upon the flap. A hole in the fingers portion enables positive positioning of the valve. Usual application of the valve is over a bore transverse to a passage which carries the valve. *Patent* 2,895,503 *assigned to International Harvester Co. by C. Paul Kolthoff Jr.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

NEW CUSHION CHAIN SHOCK ABSORBER

NOW PROTECT MACHINERY AND EQUIPMENT, BANISH BREAKDOWNS with this remarkable new device.

Simple—permanent—inexpensive! Eliminate shock loads! For chain, cable, wire rope. • For hoists, draglines, booms, snaking or logging. • For towing or tie-down. • For ships, barges, buoys. • For tensioning devices, snubbing, shock absorption.

Cushion characteristics of rubber—ultimate strength of high tensile alloy steel chain. No wearing parts. Nothing to get out of order. No tightening. No greasing. No maintenance!

COMPRESSION, TENSION and SHEAR CUSHIONING is achieved by contracting a specially dimensioned chain to its minimum length, set in unique patented mold and injected with tough rubber compound under heat and pressure. Chain links are embedded in a permanent durable bond in contracted position—the perfect shock and vibration absorber.

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HIGH CAPACITY IN SMALL SPACE

Far more efficient than mechanical, pneumatic or hydraulic devices. Example: a 2" square Cushion Chain is equivalent to 8" diameter steel spring with 1⅛" wire!

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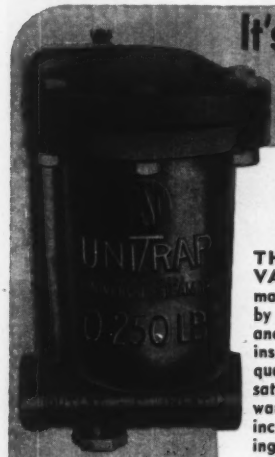

Faster Warm-Up Greater Capacity

THE EXCLUSIVE DUAL VALVE* does it. The large main orifice and valve, opened by the pilot valve by a balanced valve principle, permits instant discharge of large quantities of air and condensate. This produces faster warm-up and tremendously increases capacity. All working parts are stainless steel to minimize wear.

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"WHERE *Good Connections* COUNT"®

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1934-1959

- AIDS LUBRICATION
- UNIQUE STABILIZATION
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RESEARCH means "forward looking" with respect to new products and new techniques.

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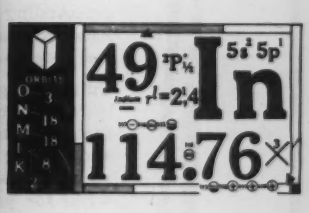

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THE INDIUM CORPORATION OF AMERICA

1676 Lincoln Avenue • Utica, New York

Since 1934 . . . Pioneers in the Development and Applications of Indium for Industry.

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THIS DRILL ELIMINATES SECONDARY OPERATIONS

Just *one* pass with these high-speed steel or carbide-tipped gun drills produces an accurate, truly round, straight hole honed to mirror-bright finish. That's why you can drill small parts of all kinds — *faster, more accurately* and at *lower cost* with HI-STANDARD Gun Drills*.

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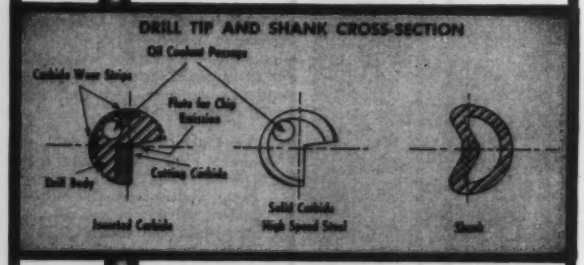

outstanding time-and-money saver. Any material that can be *machined*, can be *gun-drilled*.

Gun drilling is one important way in which forward-thinking manufacturers are increasing production and cutting costs. To find out how your company can do the same, write for your Hi-Standard Engineering File 20 *today!*

*Also called "deep-hole drills"

Pioneers in the Design and Development of Gun Drills for more than 30 Years

THE HIGH STANDARD MANUFACTURING CORP.
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Paramount Die Castings Help Reeves Pulley Co. Make Variable Speed Drive

Three castings are supplied by Paramount to Reeves for the end shields and dial wheel on the Reeves Motodrive.

Size 100 Reeves fractional h.p. Vari-Speed Motodrive with infinite variable output speed from 2.86 to 4660 rpm. Size 100 is one of a full line of Reeves Motodrives for speed control on ¼ hp. through 40 hp.

Paramount can help solve your design and production problems.

If you use die castings, it pays to investigate Paramount's complete die casting service. Their designers, sales engineers, and modern tooling and production facilities offer you an ideal die casting service.

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SEND FOR THIS HELPFUL BROCHURE . . .
A guide to Designing for Die Castings and a visit to Paramount.

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with **Pneu-Trol®** VALVES IN AIR OR HYDRAULIC USE

2,000 (brass or aluminum) and 5,000 (steel) p.s.i.

Pneu-Trol Valves combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to seat, requiring only a slight differential pressure to fully open or close it. Check Valve and Needle Valve incorporate single function features of Flow Control Valve. All valves available in S female pipe sizes — ⅛" to ¾". Valve bodies are made from brass, aluminum, steel or stainless steel. Attractive Prices — Immediate Delivery.

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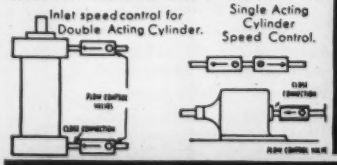

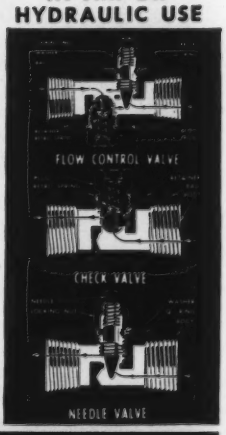

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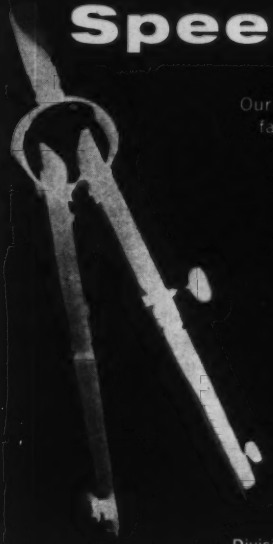

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Thor SpeedMotors

SpeedWay Mfg. Co.
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PRECISION CAM ADJUSTMENT *WITH A SCREW DRIVER...* **IN SECONDS!**

One type cam . . . no special cam lobes required.

Snap Action Switches, N. O. and N. C.—electrically separated

2 through 12 circuits. Available in NEMA 1, 4, 5, 7, 9 and 12 enclosures.

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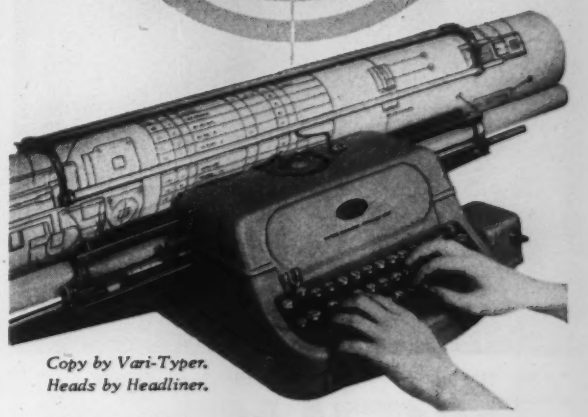

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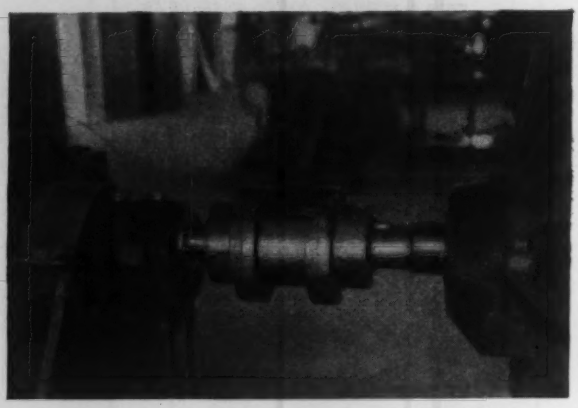

Waldron standard coupling on crude oil pumps on 20" line from Wyoming to Indiana.

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Waldron can stand behind these claims because their standard couplings are made of forged steel and are machined under controlled conditions. The two, one piece cover sleeves and spacer function as a single unit with no flexible metal parts to bend or break. Couplings are oil tight and dust and moisture free.

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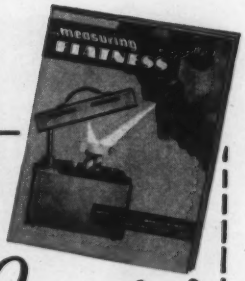

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Circle 643 on Page 19

THIS 3 in 1 **CASTING**

SLASHED **SMALL PARTS COSTS MORE THAN *50%***

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BRASS • BRONZE • ALUMINUM • BERYLLIUM COPPER

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of economical Ethyl-Cellulose for maximum service at minimum cost.

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Weckesser Cable Clamps offer superior insulating properties, high strength, light weight . . . with *no* rust or corrosion.

Non-circular shapes also available. Immediate delivery from on-hand stocks.

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Especially recommended for operation of blowers, pumps, agitators, mixers, conveyors and other machinery . . . widely used for plastic moulding, rubber curing, heat treating, enamel baking, light exposure and similar operations.

Fully enclosed. Double-throw, single-pole switch. Self-starting slow speed industrial type synchronous motor. Time range: 60 seconds to 72 hours.

Send for full information, including bulletin on Zenith's complete line of automatic control equipment.

ZENITH ELECTRIC CO.

149 WEST WALTON STREET • CHICAGO 10, ILLINOIS

Circle 646 on Page 19

BHEW

Hydraulic Cylinders

- Basic Designs
- Superior Quality
- Specific Adaptations
- Application Engineering

THIS IS BHEW'S 1500 PSI SERIES DOUBLE-ACTING GENERAL-PURPOSE CYLINDER, designed around standard components, but custom-built to suit *your* application. Available in a variety of mountings, with or without adjustable or non-adjustable rod ends.

• Self-adjusting "V" packed rod glands • "U" cup seal on pistons • Honed steel barrel • High-tensile, hard chrome plated rods • Packings for extreme high and low temperatures most non-inflammable fluids.

Production parts save you money, do the job better! BHEW basic cylinders can easily be modified to fit your *specific* product applications. You benefit from production economies; you get custom-built cylinders.

Let's discuss your design and application problems —

FREE!

Write today for Hydraulic Cylinder Engineering Reference Data — 78 dimensional basic designs for general — and special-purpose double-acting cylinders. SAVE TIME.

BENTON HARBOR ENGINEERING WORKS, INC.

622 Langley Avenue St. Joseph, Michigan

Circle 647 on Page 19

NATIONAL LOCK FASTENERS

to your "specs"

National Lock Company sales engineers will work with you in solving all your fastener problems. Our extensive engineering and production facilities are geared to handle your requirements for special-purpose or standard fasteners of uniform quality . . . delivered on time.

Write us.

"KEPS"® REGISTERED TRADEMARK OF ILLINOIS TOOL WORKS

NATIONAL LOCK COMPANY
FASTENER DIVISION — ROCKFORD, ILLINOIS

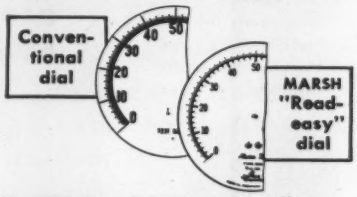
Circle 648 on Page 19

New MARSH "Master-Test" SERIES

Twin-tip pointer enables observer to read "dead-on" by lining up twin tips like gun sight.

Unprecedented accuracy and dependability in test gauges developed to meet today's exacting requirements. Each gauge individually *dead-weight tested!* Guaranteed accurate within ¼ of 1% plus or minus of maximum dial reading over entire range.

Mirror dial also insures accurate "dead-on" reading.



New "Read-easy" dial (patent pending), as illustrated above, assures reading accuracy in keeping with indicating accuracy. Also note three advanced means of reading available in all "Master-test" gauges: twin-tip pointer, mirror dial, and "non-parallax" dial as shown opposite.

Sizes 4½", 6", 8". All standard pressure ranges 0-15 psi to 0-30,000 psi, vacuum and compound.

"Non-parallax" dial has Plexiglas insert that assures accurate reading even when read at angle.

Ask for new 20 page bulletin covering all details

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Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

Circle 649 on Page 19

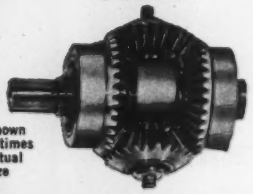
NEW!

IMMEDIATE DELIVERY STOCK PRICES

DYNACO STOCK DIFFERENTIALS

MINIATURE HOLLOW SHAFT

1/16 & 1/8"



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DIFFERENTIALS
STAINLESS STEEL

HOLLOW SHAFT • FACE GEAR • END GEAR

Cat. #HSD559-4 shown for mounting on .062" shaft, (4) ABEC 7 ball bearings, clearance dia. 0.580", displacement 15° arc.

FREE!

Send for Supplement "C" of E88 Dynaco Catalog

DYNAMIC GEAR CO. INC.
20 Merrick Road
Amityville, N.Y.

Circle 650 on Page 19

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Top performance and life.
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DESIGN SERVICE...
Solves toughest problems.
COOPERATION...
Even on small-lot orders.

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Also, Doerr quality construction assures full performance of your product . . . while compact, modern Doerr styling adds to appearance.

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DOERR ELECTRIC CORPORATION

92 N. FOURTH AVE. • CEDARBURG, WIS.

Circle 651 on Page 19

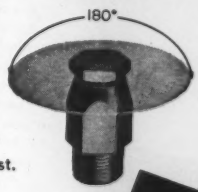
EXCLUSIVE with Steinen

New Nozzles

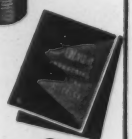
TAN-JET
SOLID CONE NOZZLES

Non-clogging nozzles having a uniform solid-cone spray pattern, furnished in brass, steel, 303 stainless or other suitable materials for any application or process which involves spraying of fluids. Sizes ¼"—⅜"—½" male or female conn.

*SPAN-JET
FLAT SPRAY NOZZLES



For spraying or washing inside of tubular units or other uses where a circular wide-angle spray is needed. Made in two patterns — 160° hollow-cone spray or 180° flat — circular spray. Available in brass or 303 stainless steel — others on request. Sizes ⅛" — ¼" — ⅜" male conn.



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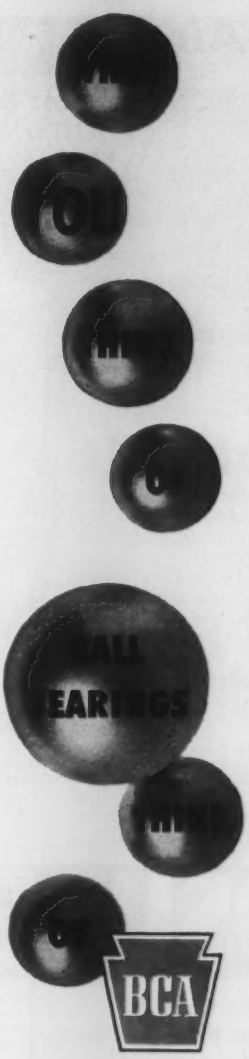

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BCA BALL BEARINGS — BEARINGS COMPANY OF AMERICA

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MEADMATIC

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A light momentary touch on limit switch actuates main valve piston—response is instantaneous! Catalog free.

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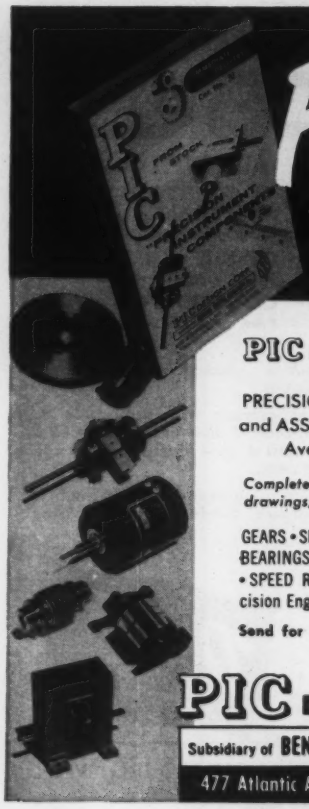

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Circle 655 on Page 19

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- Metal or Plastic Caps or Plugs to protect threads, tubes, machined parts, reamers, cutters, tools.
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- For inside and outside application. All sizes. Immediate delivery.

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City.....

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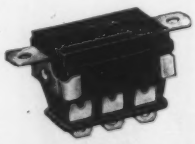

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Double Contact Area

Phosphor bronze knife-switch socket contacts engage both sides of flat plug contacts.

Socket contacts phosphor bronze, cadmium plated. Plug contacts hard brass, cadmium plated. Insulation molded bakelite. Plugs and sockets polarized. Steel caps with baked crackle enamel. 2, 4, 6, 8, 10, 12 contacts. Cap or panel mounting.

Information on complete line, in Jones Catalog 22. Electrical Connecting Devices, Plugs, Sockets, Terminal Strips. Write

Jones

HOWARD B. JONES DIVISION

CINCH MANUFACTURING COMPANY

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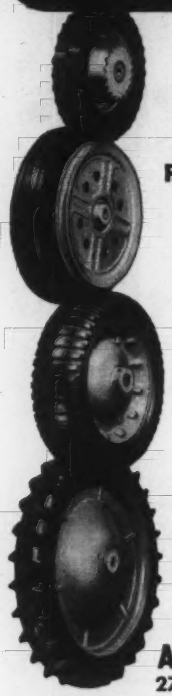
DIVISION OF UNITED-CARR FASTENER CORP.

Circle 657 on Page 19

ALLIED DIVERSE TYPES OF DRIVE WHEELS



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● Let field tested and proven ALLIED Drive Wheels solve your propelling requirements. Big selection of high production stock types and sizes, at favorable prices!

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VARIATIONS AT SMALL COST

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FREE ROLLING WHEELS TO MATCH

ALLIED offers matching companion wheels for all types and sizes of Drive Wheels—with choice of nylon, ball, or sleeve bearings. Hub caps available for all wheels too!

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Representatives and Warehouses in Fifty Principal Cities

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AJUSTRITE® CHAIRS AND STOOLS

DRAFTING CHAIR *Model RUC-2230*

- 2 inch upholstered seat
- full swivel seat
- 2-way adjustable backrest
- no soiled hands when adjusting seat
- Three sizes: 20" to 28"—24" to 32"—28" to 36"
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Also available with round metal or wood seat; or formed plywood or solid hardwood saddle seat.

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32 Models for Factories • Schools • Laboratories • Hospitals • Offices

AJUSTO EQUIPMENT CO.

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Circle 659 on Page 19

A·B·K — the bearing material of 1001 uses

The unusual properties of A-B-K Laminated Phenolic Bearings have helped engineers in widely divergent fields solve some of their toughest bearing problems.

It can be formed, machined to intricate shapes. It can be bonded to metal. It can be lubricated with water or oil. It often performs better, lasts longer than metal.

If you have a wear problem involving impact, strain or stress, friction, heat, chemical action or strength, write for our brochure, or state your requirements.

PROVED PROPERTIES

- Won't peen out
- High strength/weight ratio
- Resistance to acid, alkali, heat, abrasion
- High compression strength
- Perfect weathering
- Good machining
- Dimensional stability
- Slow, uniform wear
- Water or oil lubricated

American Brake Shoe Company — American Brakeblok Division, DETROIT 9, MICHIGAN

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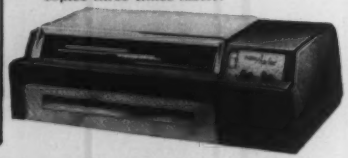
Wilbow

Bonded Rolls Speed Paper Feeding

Bonded rubber feed rolls by WILBOW help the new APECO "Auto-Stat" make copies three times faster.



The American Photocopy Equipment Company's new "Auto-Stat" produces sharp black and white copies in one fast step rather than two as required by conventional copying machines. In developing the unique paper feeding system that makes this possible, their engineers turned to WILBOW for the precision feed rolls shown above . . . neoprene rubber bonded to stainless steel and cadmium plated shafts.

WILBOW specializes in producing rubber covered rolls of all types and sizes. Whatever *your* roll requirement, check WILBOW first . . . and send for your catalog today.

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1951 South 54th Avenue • Cicero 50, Illinois • (Chicago Suburb)

Mfrs. of molded, punched, extruded and cut rubber goods. Specialists in producing rubber covered rolls, silicone rubber parts and bonding rubber to metal

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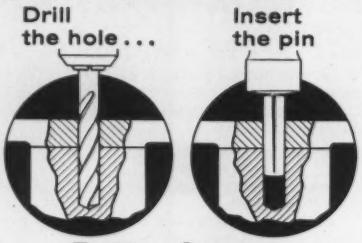
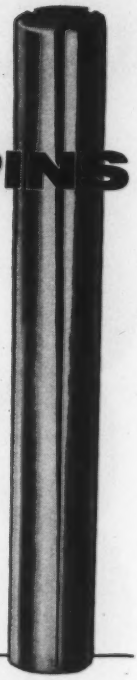
For Fast Assembly...

GILLEN GROOVE PINS

No Reaming





Fast... Secure

Saves Time and Money

3 grooves compress and reform to diameter of hole for tight positive fit . . . no tapping, no threading, no reaming.

Six types, for *many applications*, variety of lengths and diameters, all metals.

Write for information. Ask for samples.

JOHN GILLEN COMPANY

Keying and Pinning Devices

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A Subsidiary of Standard Railway Equipment Manufacturing Company

Circle 662 on Page 19

DIMCO-GRAY *Stock plastic* KNOBS...HANDLES

WRITE FOR THIS COMPLETE CATALOG

NO TOOL CHARGE!

Wide selection of stock knobs, handles and plastic parts available without tooling cost to you! Many minor changes (color, design, inserts, threads, special materials, etc.) can be made to meet your requirements.

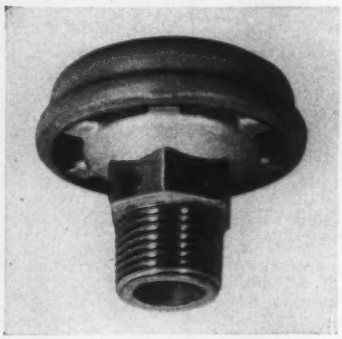
DIMCO-GRAY COMPANY

204 EAST SIXTH STREET—DAYTON 2, OHIO

Circle 663 on Page 19

BREATHER-FILTER

protects housings, crankcases, storage tanks.



The Air-Maze breather-filter keeps dust out of engine and compressor crankcases, gear-cases, hydraulic equipment, liquid storage tanks and machinery. Types and sizes available in both oil-wetted and oil bath models to protect every vented housing.

In the oil-wetted type, dust is impinged on a series of oil-wetted wire baffles. In the oil bath type, used where the dust concentration is unusually high, the filter media is enclosed in a bowl. Outside air must first pass through the oil, then the filter media, before entering crankcase or housing. Also functions as a backfire flame arrester.

Available in sizes from $\frac{1}{8}$" to $3\frac{1}{2}$". Permanent, all-metal, easily cleanable. Write for booklet BC-453. Air-Maze Corporation, Department MD-9, Cleveland 28, Ohio. (Subsidiary of ROCKWELL-STANDARD Corporation)

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Here's data on the *New*

DIAL HEAD AGASTAT®

time / delay / relays

These relays have recently been re-designed—improved in performance *and* appearance. So you'll want up-to-date specs.

This free folder gives complete details on all models. In it you'll find operating specs, timing ranges, contact capacities, dimensions, diagrams of contact and terminal arrangements, and data on mounting and installation accessories.

For your copy, write: Dept. A34-928.

AGA **ELASTIC STOP NUT CORPORATION OF AMERICA**
Elizabeth, New Jersey

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HUSCO HYDRAULIC CYLINDERS

Basic Designs Adapted to Cost-Saving Custom-Engineering

You'll solve your special Hydraulic Cylinder needs faster, at lower cost, by a quick call to HUSCO — and a custom-engineered modification of one of many HUSCO Basic Cylinder Designs . . . HUSCO Cylinders — Telescoping, Single-Acting, Double-Acting Differential Types in many sizes — offer features that assure improved performance, longer service, lower initial and operating cost, on your equipment. Write for details — or the answer to one of your problems.

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HUSCO

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Pumps • Valves • Cylinders
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Circle 666 on Page 19

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to protect customer goodwill with . . .

S.S.White PLASTIC PLUGS AND CAPS

For mere pennies you can insure customer goodwill... by protecting your products with S.S. White plastic plugs and caps. Not a chance of damaged threads, dirt, moisture, or leakage during shipping or handling. And... the extremely simple removal of S.S. White plugs and caps will demonstratably save him money and production time. They come off rapidly by hand... no shreds, no residue left in the part.

And don't forget... their rapid installation and low cost mean savings in your plant too!

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1053

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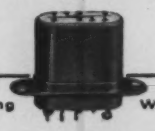
Circle 667 on Page 19

small... but **mighty**

COMAR'S SUB-MINIATURE TYPE SM



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in crystal can size

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RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

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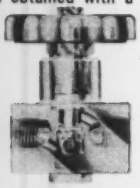
EASY OPERATION is only one of the reasons why operating engineers everywhere prefer Circle Seal 900 Series precision shutoff valves. A dead-tight seal when closed, minimum flow restriction when open, and a design which provides throttling during valve actuation, are other reasons why the 900 Series has become a favorite. The 303 Stainless Steel body of the valve easily withstands operating pressures up to 6000 psi. Trouble-free valve life is assured by use of "O" Ring seals and a unique floating sleeve that protects the "O" Ring when the valve is open. This is why engineers who know valves are specifying Circle Seal 900 Series Shutoff Valves on blueprints and on requisitions. The Circle Seal T900 Series Valve can be obtained with a quick-acting, toggle-type handle.

PLUG VALVES

CHECK VALVES



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CIRCLE SEAL *precision valves*

Complete engineering data available. Write today!

Industrial Service:
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MR. J. B. DALY
REPLIES CONFIDENTIAL

EQUAL OPPORTUNITY

RADIO CORPORATION OF AMERICA
Semiconductor & Materials Division
Somerville, New Jersey

Circle 669 on Page 19

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AVAILABLE OR WANTED

WANTED: Mechanical Engineers, B.S. and M.S. for research work on mechanical engineering problems related to the steel industry. Salary commensurate with training and experience. Large Research Laboratory, Pittsburgh Area. Forward complete resume and salary requirements to Box 950, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

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BPA NBP

backtalk—

—Meet a New Editor

Kenneth Rehor, our newest editorial staff member, was distracted from his eager editing long enough to have his picture took so he could meet the folks.

During World War II, Ken served with the Army Medical Corps; after applying his last Band-Aid, he returned to his native Cleveland to seek his fortune and was told by a friendly VA counselor that he would make a fine engineer. So, off he went to Case Institute of Technology, wherefrom he emerged four years later with a degree in mechanical engineering.

Ken has applied his learning in jobs such as tool designer, design engineer for a crane and shovel company, plant-layout engineer, and vacuum-cleaner dreamer-upper. He comes to us from the Addressograph-Multigraph Co., where he was a product designer.

For fun, Ken jumps into his gum shoes and sets out on Lake Erie in his Lightning sailboat. He is sailing squadron commander at his yacht club and is working on the club's yearbook. Not one to let his mind idle while his muscles are at play, Ken is writing a book on sailing.

—And Sauce for the Gander

Earlier in this issue (Page 166) we offered tips to engineering secretaries on performance and deportment on their jobs. It is only fair that the ladies be allowed a last word on the subject, and for this purpose we quote one of our branch-office receptionists, who recently issued a memo to male office personnel on the subject of "Female Office Personnel—Treatment of:"

The species must be washed, dressed, combed, curled, painted, fed, and watered daily. Any of these activities, observed in the office, are best ignored, unless you have kind thoughts to convey. It must be let out for exercise each morning, noon, and afternoon, if possible. Any interference with these respites may turn it churlish.

Since the species is rather vain, as suggested above, it is open to flattery, blandishments, and praise.

It likes suggestions but no direct orders, and some of its favorite words are "please," "thank you," and "when you have time." It dislikes being rushed or pressured, and will commonly retreat in injured silence if called upon to overperform.

All in all, it is best to speak softly, approach with caution, and treat with chocolates and honeyed words, as the occasion warrants.

—Happy Birthday, Dear Us

One score and ten years ago a 68-page publication, first of its kind for men in a growing field, appeared on the desks of about 7000 design engineers. In 1929, Vol. 1, No. 1 of MACHINE DESIGN, proclaimed its existence as a "technical publication . . . for those executives and engineers responsible for the creation and improvement of machines built for sale, and for the selection of the materials and parts to be used."

MACHINE DESIGN, as evidenced by this current issue, has grown and, as befits its maturity, multiplied. At first a slim once-a-monther, it is now a substantial biweekly package that is delivered to well over 50,000 addresses and read by three times that many engineers.

Three members of our original staff are still here and going strong. Other old friends and true are those 12 of our original 20 advertisers who are still with us. Four others have since gone out of business; the remaining four are not currently advertising, but have done so as recently as a year or two ago.

Since a birthday is a time for posterior-patting of some form, we are taking the liberty of applying a few proud thumps to our 30-year-old backbone. Looking back, we are satisfied; looking forward, we are confident that our journal will continue to live up to its dedicated purpose.

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for PRECISION . . . specify

ACIPCO

CENTRIFUGALLY SPUN STEEL TUBES

For almost 80 years, Morton Manufacturing Company of Muskegon Heights, Michigan, has been progressively building bigger and better machine tools.

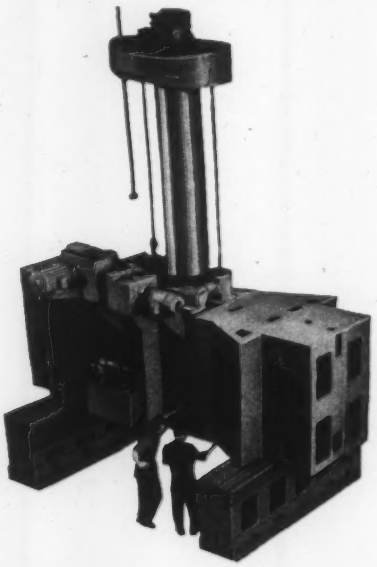
This ultra-modern turning and boring mill is 27 feet x 22 feet x 40 feet high, and weighs 525,000 pounds. Load capacity is 120,000 pounds. Driven with 210 horse-power, it is the first machine of its type wherein the work remains stationary.

Because of the herculean task this machine must perform, each component must be capable of precise performance under extreme loads. Morton wisely selected ACIPCO centrifugally spun steel tubing for the gigantic quill which houses and guides the rotary spindle. This tube is 24″ in diameter, 3″ in wall thickness and 17′6″ long.

ACIPCO centrifugally spun tubes have a dense, non-directional grain structure that has extra-ordinary strength and durability, and is more easily machined to close tolerances.

Whatever you may have in tubular applications, call on ACIPCO for perfect dependability. Our technical and manufacturing competence will serve your exacting needs.

MORTON



Morton Manufacturing Company, of Muskegon Heights, Michigan, is a leading manufacturer of heavy duty machinery for the machine tool industry. Boring mills; drillers, planers, as well as special machine tools for national defense and the development of new processes are among their products.

ACIPCO Centrifugally Spun TUBES

SIZE RANGE: Lengths up to 410″ have been produced to meet modern machinery requirements. OD'S from 2.25″ to 50″; wall thicknesses from .25″ to 4″.

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special analyses.

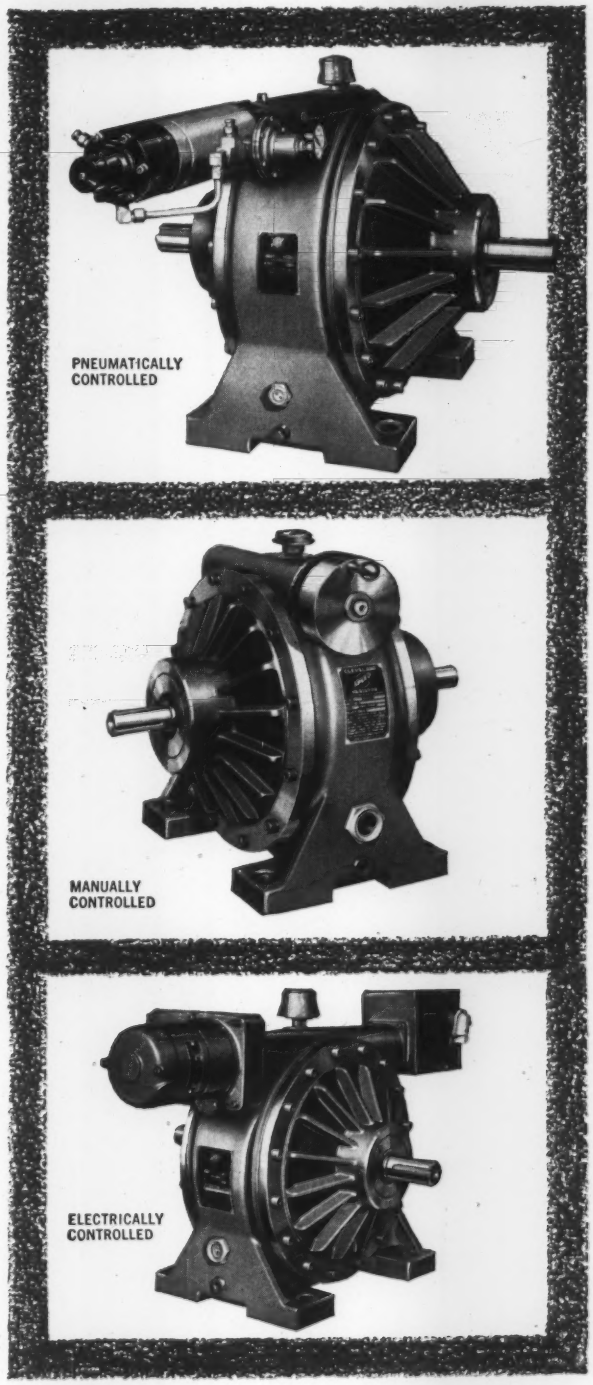
FINISHED: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.

SPECIAL PRODUCTS DIVISION

AMERICAN CAST IRON PIPE CO.

ACIPCO

BIRMINGHAM 2, ALABAMA



with Cleveland Speed Variators... precision control is a simple matter

Cleveland Speed Variators — mechanical traction-type variable drives with stepless speed control — provide both increase and decrease of output speed on a range up to 9:1 from a constant speed power source.

Infinitely variable speed regulation is provided with instant, smooth change by either manual, automatic, or remote control. Precise adjustments are easily made with accurate adherence to settings. Some typical examples.

For the Chemical Industry
In rubber processing seventeen variators provide necessary process flexibility when changing production from one type synthetic rubber to another.

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Variators give accurate control of assembly line speeds to control conveyor output rates.

For the Tobacco Industry
Variators make delicate adjustments for electronic beta gage controller.

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Variators provide remote control speed change on processing line conveyor.

For the Metal Working Industry
Variators permit fast, accurate adjustment of machining speeds for metals, from magnesium to 38 Rc steel.

For the Wire Products Industry
Variators control four reels simultaneously — and without slippage.

In Ore Processing
Variators easily adjust rate of material feed to hammermill.

In Material Handling
Variators control movement of steel tubes through 176-roll annealing furnace.

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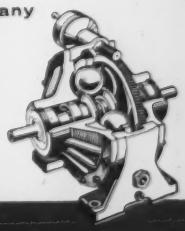

HOW IT WORKS
Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts. Relative speeds of the shafts are adjusted by changing the positioning of the axles on which the balls rotate (see cutaway view, right).

CLEVELAND
VARIATOR

Circle 402 on Page 19

Cut Production Costs with

ULTRAFLEX STATIC POWER

Adjustable Speed Packaged Drives

NO MOVING PARTS Static power conversion units have replaced the conventional M-g set. Ultraflex Packaged Drives save up to 50% in floor area . . . up to 75% in weight, permitting low cost installations or alterations without special handling equipment or floor loading preparations.

NO MOVING PARTS Ultraflex Packaged Drives work perfectly without forced ventilation . . . less power wasted as unwanted heat. No power robbing friction or windage losses. A closed-loop voltage regulation system, current limit control, and static field excitation insure peak operational efficiency.

NO MOVING PARTS Simple static power conversion units cut maintenance costs. With Ultraflex there are *no* bearings, commutators, or brushes to service. *No* shafts to align or couplings to maintain. *No* inertia loads to balance. *No* fans or filters to clean or change.

Standard Ultraflex Drives provide an 8:1 speed range with wider ranges available upon request. Optional features include dynamic braking, jogging, reversing, tachometer-generator speed regulation, etc. Get all the facts, and see how a Cutler-Hammer Ultraflex Packaged Drive can provide outstanding savings in installation, operation, and maintenance. Write today for new bulletins EN64-T243. and EN65-T243. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

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CUTLER-HAMMER CONTROL C-H

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